SCIENTIFIC AGRICULTURE

VOL. VIII JUNE, 1928 No. 10

THE BIONOMICS OF THE SPRUCE BARK-BEETLE *Dendroctonus piceaperda* Hopk.*

THE RESULT OF OBSERVATIONS CARRIED OUT IN THE ALGOMA DISTRICT OF ONTARIO.

E. B. WATSON

[Received for publication April 30, 1928.]

The eastern spruce bark-beetle, *Dendroctonus piceaperda* Hopk., is widely distributed throughout the coniferous forests of Eastern Canada; it has been recorded from Newfoundland and its range extends westward into northern Manitoba and Saskatchewan.

Although serious outbreaks have not been very numerous within the last few years, the spruce bark-beetle must always be regarded as a potential source of danger to stands of mature white spruce. Since the insect is so widely distributed and can, under favourable conditions, endanger a high percentage of standing white spruce, all foresters, forest rangers and others who have direct supervision over the timber resources of the country would be well advised to maintain a constant look-out for incipient outbreaks of the spruce bark-beetle and adopt control measures before the epidemic assumes serious proportions.

A small outbreak of the spruce bark-beetle occurred on the shores of lake Superior near Frater about sixty miles north of Sault Ste. Marie in the Algoma district of Ontario. Studies on the insect were accordingly commenced with the object of obtaining further information on the bionomics of the beetle with particular reference to the seasonal history, the economic status of secondary bark-beetles, natural control agencies and the factors resulting in the abnormal multiplication of the insect. The studies of which this article is a brief report, were entirely biological in character, all statements relating to the life-history and other data being based on field and cage observations.

CAGES

A number of the conclusions arrived at in this article were achieved through the use of cages. These in general were of three types: small cages for the study of the insects in short logs (Plate 4, A and C), cages surrounding the entire trunks of felled infested trees and cages built round the base of the trunks of living trees.

Over forty cages were constructed for the purpose of studying *Dendroctonus piceaperda* Hopk., *Ips perturbatus* Eichh. and other bark-

*Contribution from Division of Forest Insects, Entomological Branch, Department of Agriculture, Ottawa.

beetles. The objectives for which the cages were constructed may be enumerated as follows:

1. Life-history and seasonal history of *Dendroctonus* and other bark-beetles.
2. Total emergence.
3. Insect parasites and predators.
4. Number of beetles required to kill a living tree.
5. Determination of woodpecker control.
6. Overcrowding of brood in limited areas of bark.
7. Experiments with black spruce as a host tree.
8. Experiments in connection with virility of brood and host selection.

When living trees were caged, it was not found possible to cage more than the basal twenty feet at the most, in the absence of long ladders and climbing irons. The method adopted was to fix four or five balsam or cedar poles at suitable intervals apart, parallel to the trunk, and then stretch cheese-cloth tightly round the poles so that there was ample room for the beetles to move about over the surface of the trunk. The tops and bottoms were drawn tightly with wire, the irregularities in the bark being stuffed with cotton to prevent as far as possible the escape of the insects (Plate 2, A and B). A similar method was adopted when caging the entire trunk of an infested tree (Plate 3).

The early history of the outbreak at Frater is somewhat obscure; there is little doubt that a particularly heavy windfall, coincident with local spruce cutting on a small scale in 1920 and 1921, was associated with the insect becoming epidemic. The infested area was not very large in extent, the most severe injury being located near the shore of lake Superior about half-way between the Agawa and Montreal rivers.

When the district was first visited in 1924, the epidemic appeared to be on the decline and in 1925 there was a marked decrease in the number of standing trees attacked and killed by the beetle.

Dendroctonus appears to be widely distributed in the whole district between the Agawa and Montreal rivers west of the Algoma Central railway. In the neighbourhood of the Montreal river, about ten miles south of the main infestation, it was observed that approximately five per cent of the standing white spruce had been killed by the beetle.

The district covered by the *Dendroctonus* outbreak is for the most part rough and hilly; the forest types are varied but in general the tops of the hills are timbered with pure stands of sugar maple and yellow birch; in the flats and river valleys, the softwoods predominate, the general types being composed of a mixture of balsam, paper birch, cedar, white spruce, black spruce and white pine in that order of prevalence. On the shores of lake Superior there are extensive stands of red pine and jack pine.

The white spruce does not occur in pure stands but is widely distributed in scattered groups of from five to thirty trees which are for the most part mature and of large size. The scattered distribution of the white spruce in the district is probably the main reason why the outbreak has not been as

severe as those in other parts of the country; it was quite common to find a cluster of a dozen trees of which 90 per cent had succumbed to the beetle. On the other hand it was not unusual to locate groups of spruce which had been overlooked entirely by *Dendroctonus*.

In order to obtain a general idea of the percentage of timber killed by the beetle, counts of all white spruce 8" d.b.h.* and over were made in strip-surveys in three localities; the results were as under:—

HEALTHY TREES	BEETLE-KILLED TREES	PERCENTAGE OF TREES KILLED
55	33	37.5
57	24	29.6
26	10	27.7

The average percentage of beetle-killed trees was a little over thirty and this figure is probably a fair estimate of the total mortality in the district bounded on the north by the Agawa river, on the south by a line drawn from Frater station to McGregor cove, lake Superior, on the east by the Algoma Central railway and on the west by lake Superior.

Life-History and Seasonal History of *Dendroctonus*

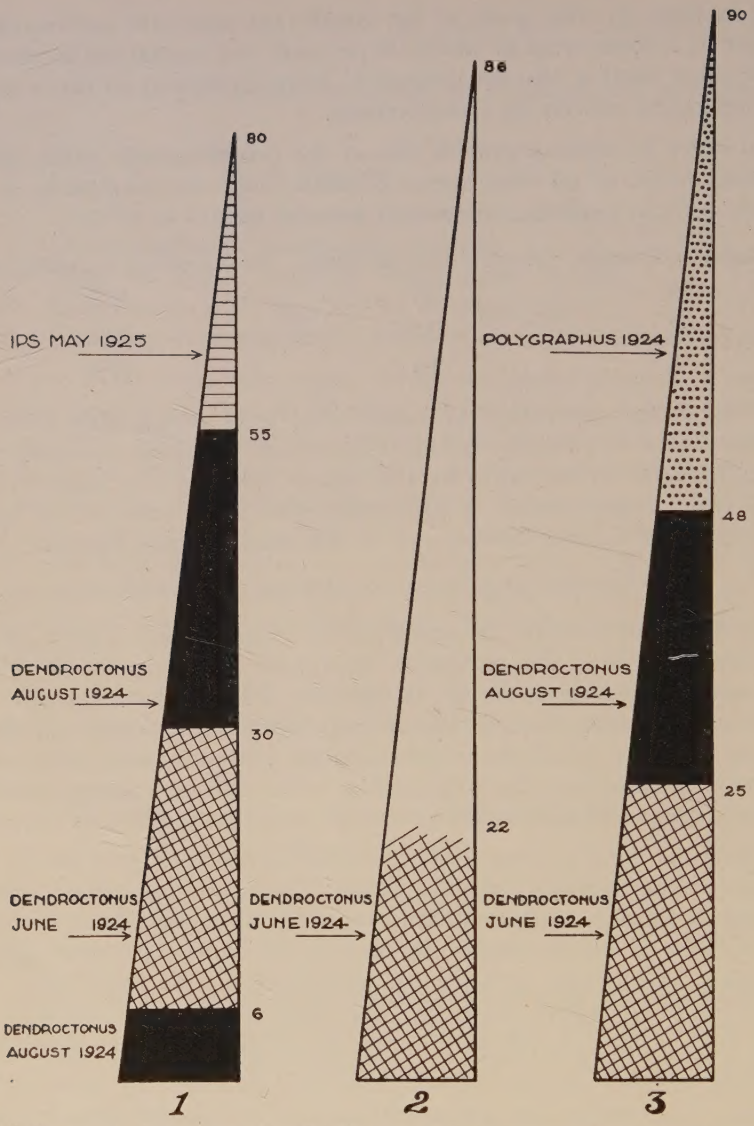
In the Frater district, the first flight of *Dendroctonus* is the largest and takes place in June, the maximum emergence occurring in the first ten days, weather conditions being satisfactory. The second flight is more protracted, occurring towards the end of July and continuing till the first week of August; this flight is generally on a smaller scale than the first one and is composed of hibernated young beetles cutting a second set of tunnels and beetles which have matured from overwintered mature larvae.

The June flight of beetles concentrates for the most part on the lower portions of the trunks of standing trees; the infestation is not usually to be found at elevations of more than twenty-five feet from the ground. The August flight of beetles affects the tops of the same trees above the June infestation, and is also to be found abundantly in the basal four or five feet of the trunk where the early June flight of beetles is often drowned out. Text Figure 1 illustrates the distribution of the *Dendroctonus* broods and secondaries in three trees attacked in 1924.

Fig. 1 represents the ordinary condition of infested trees in the district; the June attack on the butt log was successful except on the basal six feet where it was largely drowned out; a subsequent secondary attack of *Dendroctonus* in August became established there as well as on the upper trunk above the successful June attack. *Ips perturbatus* Eichh. entered the top of the tree in May, 1925.

The infestation as shown in Fig. 2 is unusual in that the tree received no secondary *Dendroctonus* attack whatever, the primary infestation extending only twenty feet up the trunk. Fig. 3 is another common type; the early *Dendroctonus* attack in the butt, which was successful in this instance, was followed by a heavy secondary flight in August, the whole infes-

*Diameter breast high.



TEXT FIGURE 1. Diagrammatic distribution of *Dendroctonus* broods and secondaries on spruce. Figures at right refer to elevation in feet above ground level.

tation extending almost fifty feet up the trunk of the tree. In this tree a slight secondary attack by *Polygraphus rufipennis* Ky. in August was evident in the top and limbs. The tree was cut down in October, 1924, and by May, 1925, the remaining uninfested portions of the trunk were too dry to support a secondary infestation of *Ips perturbatus* Eichh.

In windfalls the tops are generally filled with the brood from the August emergence, the butt of the tree being monopolised by the early brood.

No healthy trees have been observed attacked by the August brood; this is probably due to the fact that the time of emergence is so protracted,

extending as it does over a period of several weeks, that there are not sufficient beetles on the wing to make a successful attack on a green tree, whereas the June emergence period is sharply defined and large numbers of beetles are on the wing at the same time.

The brood from eggs laid in August hibernate as small larvae which develop in the following spring and mature to beetles in July or August; these young beetles do not emerge from the host-tree in the same year as their transformation to the adult stage.

This hold-over has taken place for three consecutive years and is apparently the normal occurrence in the Frater district. Since flying conditions were quite satisfactory in August 1925 and 1926, the hold-over cannot be attributed to unfavourable weather conditions.

The progeny of beetles of the June flight hibernate either as young adult beetles or as full-grown larvae. The former emerge from the tree the following June while the latter complete their metamorphosis in spring, the beetles flying in July or August. The determining factors which decide whether the brood of the June attack will reach the adult stage before winter, appear to be an abundance of light and warmth supplemented by a relative lack of resistance on the part of the host-tree. It has been observed on several occasions that the progeny of the June flight of beetles mature to the adult stage in the first season, when the host tree was situated in rather open forest with a southern exposure, and did not yield enough resin to retard to any extent the activities of the parent beetles or their newly-hatched larvae. Conversely the brood from trees yielding a copious flow of resin and located in dense forest, generally hibernated as mature or nearly mature larvae. Thus the brood from eggs laid in June have two distinct emergence periods, depending entirely on whether the winter is passed in the adult or larval stage.

The two emergence periods are as a rule sharply defined, though there is considerable overlapping when the parent beetles of the June flight emerge to cut their second set of tunnels. This flight takes place about July and synchronises more or less with the August flight proper. The following tables summarize the seasonal history of *Dendroctonus* at Frater for the years 1924 to 1926.

1924

Brood	Jan.	Feb.	Mar.	Apr.	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Brood
Hibernation Young beetles						flight	eggs	larvae	pupae	beetles			A.
								larvae			(mature)		AA.
Hibernation Small larvae								pupae	beetles	(feed only)			B.
Hibernation Mature larvae								pupae	beetles	flight	eggs	larvae	C.

1925

Brood	Jan.	Feb.	Mar.	Apr.	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Brood
A.	Hibernation												
	Young beetles					flight	eggs	larvae, pupae, beetles					a.
								larvae (mature)					aa.
AA.	Hibernation												
	Mature larvae					pupae	beetles	flight	eggs	larvae			D.
B.	Hibernation												
	Young beetles					Life-history as for "A"							
C.	Hibernation												
	Small larvae					pupae	beetles	(feed only)					C.

1926

Brood	Jan.	Feb.	Mar.	Apr.	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Brood
a.	Hibernation												
	Young beetles					flight	eggs	larvae, pupae, beetles					
								larvae (mature)					
C.	Hibernation												
	Young beetles					Life-history as for "a"							
D.	Hibernation												
	Small larvae					pupae	beetles	(feed only)					
aa.	Hibernation												
	Mature larvae					pupae	beetles	flight	eggs	larvae			

1924

Parent beetles	Tunnels	Date of attack	History of Progeny	Designation of brood
Hibernated young beetles	1st	June	Hibernation–young beetles	a
			–mature larvae	aa
	2nd	August	– young larvae	b

1925

a beetles	1st	June	Hibernation–young beetles	c
			–mature larvae	cc
	2nd	August	" – young larvae (adults emerge June 1927)	
aa beetles	1st	August	Hibernation–young larvae (adults emerge June 1927)	

1926

aa beetles	2nd	June	Hibernation–young beetles	
			–mature larvae	
c beetles	1st	June	Hibernation–young beetles	
			–mature larvae	
	2nd	August	" – young larvae	
b beetles	1st	June	Hibernation–young beetles	
			–mature larvae	
	2nd	August	" – young larvae	
cc beetles	1st	August	Hibernation–young larvae	

Secondary Bark-Beetles

The secondary bark-beetles that follow in the wake of a *Dendroctonus* attack are frequently very numerous though the number of species is small. *Ips perturbatus* Eichh. and *Polygraphus rufipennis* Ky. were the only two

species in the Frater outbreak sufficiently numerous to become even potential enemies of spruce.

Ips perturbatus Eichh. has generally been regarded as a secondary species of considerable economic importance inasmuch as it has been observed entering the unoccupied portions of the trunk of a spruce attacked by *Dendroctonus* shortly after the entry of the primary species*; such a condition does not occur in the Frater district. The emergence of *Ips* takes place several days in advance of the main flight of *Dendroctonus;* since this has occurred every year for four consecutive years and *Ips* has not been found breeding in spruce infested by *Dendroctonus* in the current year of attack, it is safe to assert that so far as this district is concerned, *Ips* is of no economic importance whatever.

The *Ips* infestation in the Frater area is confined almost exclusively to the tops of trees killed by *Dendroctonus* the previous year, provided the infestation of the latter has not extended too far up the trunk; in that event the bark would be too dry to support a secondary infestation of *Ips* and only a few *Polygraphus* and *Dryocoetes* would mature.

In trees in which the *Dendroctonus* attack is confined to the basal thirty or forty feet, however, the bark on the remainder of the trunk will be sufficiently moist and fresh to support a secondary infestation by *Ips* in the following year, though the tree has been virtually killed by the girdling effect of the *Dendroctonus* brood in the lower trunk for approximately ten months. *Ips* is also abundant in windfalls and, on account of their earlier emergence, they not infrequently monopolise the whole trunk, leaving very little space for other bark-beetles.

The winter is always passed in the adult stage; flight generally takes place towards the end of May, weather conditions being favourable. The eggs hatch quickly and the resultant larvae also mature rapidly. The parent beetles sometimes leave their first tunnels and cut a second set, but this is not always the case as dead parent beetles are not uncommon in their first set of tunnels. Parent beetles, after cutting two sets of tunnels, could not be induced to cut a third set under cage conditions. The second brood also mature rapidly and transform to the adult stage before winter. Pupation in the first brood takes place in July and the young beetles feed very extensively throughout the late summer and early fall but do not fly to freshly infested trees or windfalls before spring.

Hibernation takes place in the ground, in pieces of decaying wood, under moss and dead leaves and in similar places. Young beetles, fully matured and dark brown or black in colour, could not be induced to fly in the late summer months; they appear to be extremely intolerant of light and when removed from under the bark of their host-tree and placed in the sun, invariably sought shelter even when the shade temperature was in the neighbourhood of 80°F. Young beetles removed from their hibernating quarters in the following May, however, and placed in the sun, soon showed signs of activity and generally took to the wing in a short space of time.

*J. M. Swaine, Pamphlet No. 48, New Series, Dominion Department of Agriculture, Ottawa.

The table submitted below illustrates the life-history of *Ips perturbatus* Eichh. in the Frater district.

Jan.	Feb.	Mar.	Apr.	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Hibernation (Young beetles)				flight	eggs	larvae	pupae	beetles		Hibernation (Young beetles)	
			(2nd tunnels)			eggs	larvae	pupae	beetles	Hibernation (Young beetles)	

Polygraphus rufipennis Ky. is a very abundant species, affecting as a rule the extreme top and limbs of dying spruce, though their tunenls are also to be found on the trunks of trees of large dimensions. This beetle has not been found to be sufficiently abundant in spruce attacked by *Dendroctonus* in the Frater outbreak to affect materially the resistance of the trees. There is definite evidence that *Polygraphus* will enter the tops of trees attacked by *Dendroctonus* in the same year; in common with other bark-beetles, however, they have a decided preference for windfalls, slash and the tops of trees killed the previous season.

Dryocoetes affaber Mannh., *Dryocoetes americanus* Hopk., *Dendroctonus johanseni* Sw., *Scierus annectens* Lec. and *Trypodendron bivittatum* Ky. are other species of bark-beetles associated with dead or dying white spruce; none of these can be considered as insects of actual or potential economic importance. After a careful study of a number of individual trees attacked by *Dendroctonus,* it is the writer's belief that, so far as the Frater district is concerned, secondary bark-beetles do not offer any assistance whatever to the primary species in overcoming the resistance of the trees. The only secondary bark-beetle that is large enough and sufficiently numerous to be considered in the light of an economic species is *Ips perturbatus* Eichh. and this species, as mentioned previously, enters only dying spruce in the year following the primary attack by *Dendroctonus.*

Effect of Windfalls and Slash in Promoting an Outbreak

The partiality of *Dendroctonus* for fallen timber in preference to green, standing trees is such, apparently, that enormous numbers of beetles must mature before the beetles will attack standing timber. When the beetles are so numerous that there are not sufficient supplies of dying bark in which to breed, they are forced to attack living spruce and will continue to do so, until natural or artificial control measures reduce their numbers to such an extent that the usual supplies of fallen timber in the forest can accommodate them.

In the past it has been ascertained that *Dendroctonus* outbreaks have originated through the presence of a super-abundance of suitable breeding material such as windfalls, culls and slash.

The Frater outbreak can be attributed for the most part to an excessive windfall of mature white spruce, though there is some evidence that local spruce cutting has also been partly responsible. In this operation there were some trees of large size felled in the winter and then left in the bush on account of heart rot or unsatisfactory hauling conditions; these trees were just as satisfactory to *Dendroctonus* as windfalls and filled up with beetles immediately the June emergence took place.

Dendroctonus seldom breeds in timber, either fallen or standing, less than five inches in diameter and the tops of the trees left in the bush at Frater did not show indications of having bred out a large number of beetles.

In Northern Ontario, the spruce is more often utilised for the pulp and paper industry rather than as saw timber and consequently the slash is generally too small in diameter to be suitable for *Dendroctonus*. In districts where the spruce is cut for lumber, it would be quite common to find tops measuring up to ten inches in diameter and there would be a certain percentage of faulty logs left in the bush as culls; these would be likely to produce a large quantity of beetles and might therefore constitute a hazard in districts where the insect is prevalent. Similar conditions may be expected in areas where the spruce is cut for the manufacture of high quality paper; faulty logs and limby tops are unsuitable and are consequently often left in the bush.

Stumps of freshly cut spruce were not very productive of beetles in the Frater district; in standing timber, however, attacked by *Dendroctonus*, the base of the trunk and the roots are usually well filled with beetles and comparatively large numbers of beetles emerge from that portion of the tree, as the woodpeckers are averse to working so close to the ground and the snow protects the beetles in the stump for about six months in the year.

Windthrown trees undoubtedly constitute the most favourable factor in the increase of *Dendroctonus;* it has been observed repeatedly that a higher average emergence takes place from windfalls than from any other breeding medium, apparently on acount of the comparative immunity from woodpeckers and the fact that there is no resin-flow to overcome the beetles.

The windfall of mature white spruce is unusually heavy at Frater, due largely to the high percentage of trees affected with the fungus *Trametes pini;* this disease, which affects both the heartwood and the sapwood, is usually confined to the butt. Most of the windfalls at Frater were diseased trees which had broken off close to the ground, usually at a height of from two to six feet. The district is also exposed to the gales from lake Superior, the equinoctial gales, in particular, resulting in a heavy downfall of spruce and balsam.

Natural Enemies

The natural enemies of the spruce bark-beetle fall into two main classes, parasites and insectivorous birds. In the course of cage studies it was ascertained that a small percentage of *Dendroctonus* was parasitised by the hymenopteron *Cerobracon secundus* Dalla Torre. This species is not very abundant, the percentage of *Dendroctonus* brood parasitised being less than five per cent; as the outbreak subsided, the percentage increased somewhat. A dolichopodid parasite, *Medetera vanduzeei* Curran, was also taken in small numbers. The economic importance of parasites at Frater is practically negligible.

Predatory insects were of no economic value in the Frater outbreak; it is well known that *Dendroctonus* is preyed upon by certain species of *Cleridae* in Western Canada, but these predaceous beetles are not sufficiently numerous in the Frater area to be of any economic importance. One species, *Thanasimus*

dubius Fab., was not infrequent on infested trees in 1924, was scarce in 1925 and was not seen at all in 1926.

The only insectivorous birds observed at Frater feeding on *Dendroctonus* were woodpeckers of the following species:—the Pileated (*Phloeotomus pileatus*), the Hairy (*Dryobates villosus*) and the Arctic Three-toed (*Picoides arcticus*), all of which breed in the district. These birds apparently constitute the only really effective natural control of the insect in that section of the country; enormous numbers of *Dendroctonus* larvae and adults are destroyed by them in infested standing timber. The thin bark of the spruce renders the task of extracting the larvae and beetles a comparatively simple one, though the birds are quite capable of removing the thick bark of mature white pine in their search for the larvae of *Monochamus* beetles and the brood of *Dendroctonus rufipennis* Ky.

Woodpeckers have a decided preference for the brood in standing timber and it is on these trees that the control is most thorough; while windbroken spruce are also subject to woodpecker control to a slight extent, it is generally only the underside that is favoured by the birds. When the trunks of windfall spruce remain raised about four or five feet from the ground, a considerable area of the tree is accessible to the birds (Plate 4, B); in such trees about fifty or sixty per cent of the brood are consumed. A higher percentage of brood mature from trees which break off completely and lie more or less prone on the ground, as the birds cannot reach the underside and generally ignore the upper surface, though the beetles may be very plentiful beneath the bark. Moreover such trees are often covered by the first fall of snow, leaving the brood undisturbed for the remainder of the winter.

Woodpeckers are more effective on the beetle-trees in the winter months, probably because other sources of food are less readily available. The birds have, however, been observed to feed on the broods of *Dendroctonus* and *Ips* as early as July and August. Occasionally they overlook certain areas of bark on infested trees with the result that large numbers of beetles mature therefrom; this is more likely to occur in the early stages of an outbreak.

There seems to be no doubt that woodpeckers are attracted to a *Dendroctonus* outbreak from surrounding districts; woodpeckers were noticeably more abundant near Frater than in other parts of Northern Ontario visited by the writer in that season. An abundant source of food supply throughout the year would probably insure a higher percentage of young birds maturing and remaining in the neighbourhood. As the outbreak on standing timber declines, the percentage of brood destroyed by the birds apparently increases.

When working on a standing tree the birds have a decided preference for the full-grown larvae and young adults that are the progeny of the June flight of beetles; the small larvae, progeny of the August attack, are left more or less alone. These larvae in accordance with the seasonal history outlined in a previous chapter, mature to beetles the following summer but do not emerge that year and are therefore subject to woodpecker control in the second winter that they pass under the bark of the host-tree.

The following experiments were conducted in an effort to establish a fairly accurate determination of the percentage of beetles destroyed by woodpeckers in the winter months. In October, 1926, three spruce trees were selected which had been caged with beetles on the basal ten or twelve feet of the trunk in the previous June and had died as a result of the attack. The framework and cage covering were removed from the lower five or six feet of the cage so that the brood, which were at that time fully matured young beetles, would be exposed to the attentions of woodpeckers all winter, while the covering was retained on the upper part of the cage, leaving the brood unmolested.

In 1927, before any emergence had taken place, the trees were cut down and the brood and successful tunnels counted in the exposed and in the protected sections of the trunk in each of the three trees.

It is of course manifestly impossible to give a perfectly accurate determination of the number of insects destroyed by woodpeckers, when the original population is not known and moreover cannot be known without resorting to the expedient of bark-stripping. The percentage of brood consumed by woodpeckers has been calculated on the hypothesis that the beetle population per tunnel in both exposed and protected sections would be approximately equal. The area of infested bark was about the same in the upper and lower sections in all the cages and it is reasonable to assume that, with an equal distribution of tunnels over the trunk, there were originally as many beetles per tunnel in the lower section before woodpecker control as there were in the upper, protected section.

The results from these cages are as follows:—

(1)	Number of beetles in upper section	802
	Number of tunnels in upper section	118
	Average number of beetles per tunnel	7
	Number of beetles in lower section	22
	Number of tunnels in lower section	111
	Average number of beetles per tunnel	0.2
	Percentage of beetles consumed by woodpeckers	97.2
(2)	Number of beetles in upper section	1100
	Number of tunnels in upper section	105
	Average number of beetles per tunnel	10.4
	Number of beetles in lower section	5
	Number of beetles in lower section	127
	Average number of beetles per tunnel	0.04
	Percentage of beetles consumed by woodpeckers	99.6
(3)	Number of beetles in upper section	1417
	Number of tunnels in upper section	59
	Average number of beetles per tunnel	24
	Number of beetles in lower section	29
	Number of tunnels in lower section	85
	Average number of beetles per tunnel	0.4
	Percentage of beetles consumed by woodpeckers	98.8

The average percentage of the insects consumed by woodpeckers in the exposed sections of these cages is therefore a fraction over 98.5 per cent

Total Emergence

The number of beetles that emerge from an infested spruce depends on a variety of factors such as the number of beetles that enter the tree, the number of tunnels that are drowned out, the degree of excessive overcrowding and finally the percentage of the brood consumed by woodpeckers. A proportionately higher number of beetles emerge from windfalls for reasons mentioned in preceding paragraphs. A 16″ d.b.h. windfall spruce yielded over 4000 beetles ready to emerge; another windfall spruce measuring 12″ d.b.h., produced 3751 beetles from 553 tunnels, yielding an average of nearly 6.8 beetles per tunnel.

A standing tree attacked by *Dendroctonus* in June and August 1924, was cut down and caged before the woodpeckers could effect any control; the tunnels numbered 1041 with a total emergence of 8802 beetles. This is the greatest number of beetles that has been taken from a single tree in the Frater outbreak; it must be remembered that such a high emergence would not have taken place unless measures were taken to protect the brood from woodpeckers.

The number of beetles emerging from standing trees subjected to woodpecker control, however, would not be likely to exceed one thousand beetles at the most. It was not found possible to obtain definite data on this subject as the trees had to be bark-stripped in order to count the brood that had survived the attentions of the birds. In accordance with the seasonal history the progeny of the early infestation pass the winter as young beetles or full-grown larvae; flight from this brood would take place the following year in June or August respectively and it was found that this brood had suffered very heavily, over ninety per cent of the brood having been destroyed by woodpeckers. The brood of the later infestation, on examination in the spring following the attack, were small larvae which had suffered only a slight control from the birds; these small larvae would have matured through the summer but would have to pass a second winter under the bark as young beetles and would therefore be subject to the usual heavy control by woodpeckers. When counts of brood in such trees were made, all stages of the insect were counted together, so that the percentage of control under these circumstances was decidedly low.

It was not considered advisable to let the tree stand over two winters, as the progeny of the earlier attack would have emerged and the only figures on woodpecker control in that instance would apply to the progeny of the August attack.

The following data are more or less typical of standing, infested trees subjected to woodpecker control:

(1) 16″ d.b.h. spruce attacked in June and again in August, 1924: cut down and examined May, 1925, before any emergence had taken place. The total number of beetles and larvae numbered 2554, the survivors of the brood from 925 tunnels. This gives an average of approximately three *Dendroctonus* per tunnel. As a number of the brood were still small larvae, the progeny of the August infestation, they would have been forced to pass another winter under the bark as beetles to emerge in June, 1926, and would therefore have suffered heavily from woodpeckers during the winter 1925-1926, with the result that the average per tunnel would have been still further reduced.

(2) 15" d.b.h. spruce, June, 1924, attack, cut down in May, 1925. The *Dendroctonus* attack was entirely successful but confined to the base of the trunk.

Statistics:—

Total height of tree	86	feet
Highest tunnel	22	"
Attack most severe	15	"
Number of tunnels	540	
Total brood removed from tree	878	
Average per tunnel	1.6	

Woodpecker work was very extensive indeed on this tree during the winter 1924–1925 and the amount of bark removed by the birds in their quest for the brood would have been sufficient to cause the death of the tree, apart from the activities of the beetles. When cut down in May, 1925, there had been no secondary attack whatever. The leaves which were still fresh and green, showed no tendency to fall. Although this tree was virtually killed by the *Dendroctonus* brood in the base of the trunk, it is quite possible that the leaves would have remained on the tree throughout the summer, unless there were a secondary flight of *Dendroctonus* or *Ips* to the upper trunk later in the season.

34 per cent of the surviving brood from this tree were located in the stump and roots, where the woodpecker control had not been so effective.

The low average emergence per tunnel from the two trees mentioned above, is typical of infested, standing timber in the district and differs materially from the average windfall emergence figures of seven and eight beetles per tunnel in the same locality.

Overcrowding

In addition to the natural control factors mentioned previously, there is one other element that affects materially the total emergence from an infested tree. When the tunnels are very numerous, the competition among the larvae for sufficient nourishment is very keen indeed and large numbers fail to reach maturity through overcrowding and consequent starvation. Under cage conditions where the woodpecker control factor was not in evidence, it was found possible to obtain an accurate percentage of the number of larvae that died through starvation. The average number of eggs laid in the Frater outbreak was 78* per tunnel, and the largest number of eggs observed in one tunnel was 153. The average figure was reached by counting the eggs in 165 tunnels in a windthrown white spruce in July, 1925.

At the time of counting, a proportion of the eggs had commenced to hatch, while other tunnels were not yet completed so that the average figure of 78 eggs per tunnel quoted above is probably a low estimate. At such a conservative figure, however, it was calculated that 86.7 per cent of the larvae were starved out in a 22" d.b.h. infested white spruce.

In arriving at this figure, a reduction of five per cent from the total emergence had been effected to compensate for parasites.

The tunnels on the tree referred to above were not unusually plentiful when the area of the trunk is taken into consideration; it was estimated that there were five tunnels per square foot of bark on this tree. Under cage conditions where beetles are forced to breed in a more or less limited area of bark, the figures are somewhat variable, the percentage of brood starved out

*The number of eggs laid per tunnel in the Gaspé Peninsula, Que., averaged as high as one hundred; in such an instance the percentage of brood starved out through overcrowding would be considerably in excess of the figures quoted for the Frater outbreak, provided the tunnels were as abundant on infested trees as they were at Frater.

varying from 77.5 to 92.3; in the latter case there were as many as fifteen tunnels to the square foot of bark. It is not possible to determine with any degree of accuracy the number of beetles to be found in a specified area of bark; it was not uncommon in heavily infested trees to find small pieces of bark with an average population per square foot ranging from ninety to two hundred and fifty beetles. Under cage conditions it was ascertained that the butt log of a living tree, caged with 1500 beetles, contained on an average, 114 beetles per square foot of bark over an area of 44 square feet of infested trunk. Such a condition would not occur under natural conditions on account of woodpecker control and a wider distribution of tunnels over the trunk of the tree.

Number of Beetles Necessary to Kill a Healthy Tree

The actual number of beetles necessary to kill a healthy spruce varies according to the size of the tree attacked, the ability of the tree to drown out the invaders by a copious flow of resin and the distribution of the tunnels on the trunk. It is conceivable that ten pairs of beetles could kill a 12″ d.b.h. spruce by placing their tunnels at intervals of four inches apart all at exactly the same height from the ground. Assuming that such an event took place and that the tunnels were successful, the effect would be to girdle the tree completely and consequently cause its death, though the leaves would not fall for about twelve months after the attack. Such an attack would be similar to bark-stripping a tree with an axe for a few inches all around the trunk; in either case the death of the tree is certain. It is extremely unlikely, however, that a few pairs of beetles would place their tunnels in such a manner; there is, however, a strong tendency for the beetles to congregate at the base of the tree; it is there that the tunnels are most abundant. There is no hard and fast rule for estimating the number of beetles necessary to kill a spruce; five hundred beetles may easily kill one tree and be a failure in another. It is quite common to find beetles congregating in one spruce and filling up fifty feet of the trunk with tunnels and leaving an adjoining tree alone, although there were enough beetles in the first tree to kill both spruce by occupying the basal twenty-five feet of each. One hundred beetles clustered around the base of a spruce might be fatal to a tree, whereas the same numbr of beetles scattered over the entire trunk would have little or no effect.

In the Frater district, under natural conditions, it was unusual to find trees with less than 350 tunnels; the lowest number was 320, though most trees averaged over 500. In many instances tunnels in trees over 15″ d.b.h. numbered over 900; the greatest number of tunnels noted in a spruce was 1041: this tree measured 22″ d.b.h., the *Dendroctonus* infestation extending fifty feet up the trunk.

Under cage conditions, it was found that from 500 to 750 beetles could easily kill trees about 12″ d.b.h. when caged with the basal ten feet of the trunk. As a rule, however, there is a strong tendency for a large number of beetles to occupy one tree, rather than divide forces and kill two or three trees.

The number of beetles necessary to kill the tree is of little practical importance as usually more than twice the number of beetles enter a spruce than are actually required to kill it.

Resin Flow

The entry of the beetle into the bark of a living spruce causes a considerable flow of resin into the wound thus made; the resin-flow of white spruce varies considerably in quantity; the exudation in some trees when wounded is very copious indeed and in others may be almost non-existent. The exact reason for this variation is unknown to us. The reaction of the tree to the beetle attack by a heavy exudation of resin may be such as to drown out completely every tunnel in the tree. There appears to be no correlation between the annual increment of the tree and the volume of resin; extremely slow-growing trees have been observed to overcome completely a *Dendroctonus* attack as readily as those which were fast-growing. Conversely, many fast-growing and apparently healthy spruce fall easy victims to a beetle attack, making practically no resistance in the form of an exudation of resin. The variation in resin-flow in large and small trees is illustrated in the following examples; a moderately heavy *Dendroctonus* attack took place on a small, heavily suppressed spruce measuring 9″ d.b.h.; the tree was growing very slowly, the last ten years' growth not exceeding five millimetres radial increment. Every tunnel in this tree was completely drowned out by a very copious flow of resin; the writer has observed few trees which could yield such a heavy flow. This is remarkable when the growing conditions of this particular tree are considered, for in addition to being slow-growing and suppressed, the heart of the tree was so badly affected with the fungus, *Trametes pini,* that there was only one half-inch of sound wood at the periphery of the trunk. Fast-growing trees have also been observed to yield considerable quantities of resin but this is not always the case, as in the following example. A 16″ d.b.h. spruce, the last ten years' radial growth of which measured thirteen millimetres, was easily overcome by a *Dendroctonus* attack in 1924, less than five per cent of the tunnels being drowned out. These are but two examples to show the apparent inconsistency of the resin-flow in relation to the growth of the tree. Some further experiments on this project were commenced in 1926. Three living spruce were selected of about the same age and size (12″ d.b.h.). The trees were all quite close to one another; one tree was making rapid growth (16 mm. in the last ten years), another was making average growth (12 mm. for a similar period of time) and the third was slow-growing (8 mm. in last ten years). Seven hundred and fifty beetles were placed in a cage surrounding the basal ten feet of the trunk of each tree in June, 1926; the results noted in May 1927, are as follows:

(1) *Fast-growing tree*: Tree living; every tunnel drowned out; resin-flow very copious.

(2) *Average-growing tree*: Tree dead; every tunnel successful; resin-flow weak, pitch-tubes small or absent.

(3) *Slow-growing tree*: Tree dead; resin-flow fairly heavy, pitch-tubes large; 14% of tunnels drowned out.

In the first flight of beetles to a tree, an average of eleven per cent of the tunnels are drowned out; in later attacks on the same tree, very few tunnels are drowned out as the resistance of the tree is overcome after the first wave

of beetles has become established. The drowned out tunnels are usually concentrated on the butt, as it is there that the beetles first enter the tree.

Virility of Brood

The theory has been raised that *Dendroctonus* might experience some difficulty in attacking green, standing timber after breeding for several generations in windfalls or culls. It is conceivable that the beetle might lose some of its power under circumstances where it has not to contend with the resistance of a living tree and that such beetles might be easily overcome by a comparatively feeble resin-flow, whereas beetles which had been bred from standing timber might be better fitted to resist the resin-flow of the living trees.

It had been suggested that slash-bred beetles might have a decided preference for weakened bark and might decline to enter green, standing timber. Experiments were conducted at Frater to investigate this theory. Young beetles removed from under the bark of windfalls were induced to breed for two successive generations in caged spruce logs and the resultant progeny placed in a cage surrounding the basal ten feet of the trunk of a living, 13″ d.b.h., white spruce. The attack was entirely successful and compared favourably with other attacks on standing timber in the neighbourhood. Where not subjected to woodpecker control, a high percentage of beetles matured; an examination in the spring following the attack showed that about ten beetles matured per tunnel in the cage. The question as to whether the beetles would have exhibited any preference for slash under these circumstances, has yet to be settled.

Trap-Trees

Experiments were conducted at Frater to ascertain the value of girdled trees in attracting beetles in preference to other breeding media; the results would indicate that girdled trees are apparently of no value for purposes of artificial control; six trees girdled through to the heartwood in the autumn, only attracted a few pairs of beetles of the August flight in the year following the girdling. In another instance, *Dendroctonus* ignored a girdled tree and entered a 15″ d.b.h. standing spruce less than twenty yards away. An occurrence on somewhat similar lines took place when a tree which had been girdled in September, 1924 was blown down in July, 1925; though the beetles had ignored the tree in June when it was standing, they entered it in numbers shortly after it fell down.

Trees cut down close to the ground and left in a horizontal position were much more acceptable to *Dendroctonus*, a decided preference being exhibited for trees cut down in spring to those felled the previous fall. There is some indication that this insect prefers trees in a horizontal position to those that are more or less perpendicular. A spruce was cut through completely and lodged in the fork of a birch at an angle of about 80 degrees from the ground; as a control, another spruce was felled and left horizontal a short distance away; the beetles entered the latter in numbers, ignoring the former completely.

Trap-trees undoubtedly would be of useful service in the control of *Dendroctonus piceaperda* Hopk. To obtain the best results, spruce should be cut down in winter or spring. Large trees should be selected where-

ever possible in districts where the insect is most prevalent, so that as large a number of beetles will be trapped with a minimum sacrifice of timber. Girdling, fall cutting and the use of small spruce as trap-trees are not recommended.

Numerical Relationship of Sexes

The two sexes of *Dendroctonus piceaperda* Hopk. are present in approximately equal proportions as can be expected from a monogamous species. Eighteen hundred beetles taken from beneath the bark of an infested spruce, were examined and separated according to sex: 44.4 per cent were males and 55.5 per cent were females.

Host Trees

In the Frater district, *Dendroctonus piceaperda* Hopk. breeds exclusively in white spruce (*Picea canadensis* B.S.P.). In the Maritime Provinces it has been found breeding in red spruce, (*Picea rubra* Dietr.) and has also been recorded from black spruce (*Picea mariana* B.S.P.). Under natural conditions at Frater, black spruce is totally immune from attack by the beetle even when the trees are of moderate size. Black spruce trees cut down and left lying in the bush in the neighbourhood of infested white spruce, did not attract any *Dendroctonus* whatever; this experiment was repeated several times. The only bark-beetles that have been taken from black spruce in this district were *Polygraphus rufipennis* Ky., *Dryocoetes americanus* Hopk., *Ips pini* Say and an undescribed species of *Pityophthorus*.

Several cage experiments were commenced with a view to forcing *Dendroctonus piceaperda* Hopk. to breed in black spruce; several hundred beetles were caged with logs of black spruce in the early summer; most of the insects forced an exit from the cage, though a few pairs entered the logs and laid eggs, the resultant larvae maturing to the adult stage before winter. *Ips perturbatus* Eichh. has also been induced to breed successfully in black spruce under cage conditions, though the insect has never been observed breeding in black spruce under natural conditions in the Frater district.

Selection of Trees by Dendroctonus

It has generally been assumed that *Dendroctonus piceaperda* Hopk. exhibits a preference for weakened bark in any form such as windfalls, culls and slash. In small outbreaks there are grounds for believing that they practice some method of selection when attacking standing timber; at the height of a heavy outbreak, however, when over fifty per cent of the standing spruce are affected, some of the fastest-growing trees in apparently perfect health are attacked and killed.

The theory of haphazard or chance selection is, of course, quite possible and the instinct of the beetle to follow in the wake of others of its kind may support this view; that is to say, if the first few pairs of beetles that emerge, alight upon and enter a spruce, regardless of its size, growth and dominance, then the presence of those beetles and their work attracts other beetles to the same tree.

It has been stated frequently that large trees are preferred by *Dendroctonus,* but the numerous exceptions that have occurred do not corroborate this statement. The average diameter of 132 healthy spruce, measuring 8″ d.b.h. and over, was 12.8″.

The average diameter of 110 beetle-killed spruce was as low as 12.4″; since many of these trees measured over 20″ d.b.h. there were a correspondingly large number of trees eight or nine inches in diameter which had been attacked and killed by the beetle, so that, so far as the Frater district is concerned, no particular preference is shown for the larger, mature trees.

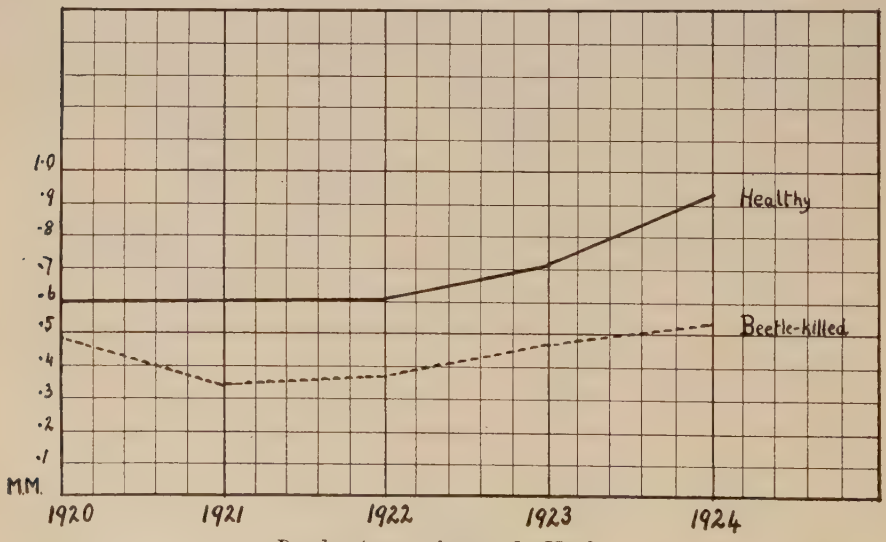
When comparisons of the radial growth of healthy spruce and beetle-killed trees were made, some interesting results were obtained. The average radial growth for the last ten years (1914-1924) of the healthy spruce was 9.515 mm. and in the beetle-trees this was as low as 5.995 mm. The difference is quite marked and shows that *Dendroctonus* does exercise a preference for the slow-growing trees; there were, however, some interesting exceptions where *Dendroctonus* had attacked and killed some very fast-growing trees and had also left alone for no apparent reasons a large proportion of slow growing spruce.

Three points of interest are connected with the measurements of a number of spruce cores:—

(1) 37.8% of the healthy trees *did not show as much growth* (in the ten year period) as the *average* growth of the beetle-killed trees.

(2) 10.9% of the beetle-trees made more growth (in the ten year period) than the *average* of the healthy spruce.

(3) Only 6.8% of the healthy spruce made more growth than the maximum growth found in the fastest-growing beetle-tree.



Dendroctonus piceaperda Hopk.
Frater, Ont.

Text Figure 2. Graph showing average radial growth in millimetres of healthy and beetle-killed white spruce for years 1920-1924.

Text Figure 2 gives an accurate comparison of the rates of growth in millimetres of healthy and beetle-killed spruce for the individual years 1920-1924 inclusive.

The following table illustrates the more important points connected with the growth of the healthy and beetle-killed trees. The figures are calculated from cores from 132 healthy trees and 110 beetle-killed spruce.

HEALTHY TREES		BEETLE-TREES	
Average growth for last ten years (1924-1914)	9.515 mm.	Average growth for last ten years	5.995 mm.
Average growth for 1924	.935 mm.	Average growth for 1924	.539 mm.
Average growth for 1923	.715 mm.	Average growth for 1923	.470 mm.
Average growth for 1922	.605 mm.	Average growth for 1922	.368 mm.
Average growth for 1921	.600 mm.	Average growth for 1921	.347 mm.
Average growth for 1920	.600 mm.	Average growth for 1920	.495 mm.
Maximum growth for healthy spruce in years 1924-1914	28.325 mm.	Maximum growth for beetle-tree in last ten years	17.930 mm.

LEGEND TO PLATES

Plate 1

A. Timber killed by the spruce bark-beetle.
B. Two trees killed by the spruce bark-beetle; note the effect of woodpeckers on the trunks.

Plate 2.

A. Framework for cage on a living spruce.
B. Living tree caged with beetles.
C. Tunnels of *Dendroctonus piceaperda* Hopk. on the trunk of a spruce.
D. A large spruce killed by the spruce bark-beetle.

Plate 3.

A large, heavily infested spruce caged for total emergence.
A. Completed cage.
B. Covering removed to show framework.
C. After emergence of beetles; bark removed to show tunnels on wood surface.

Plate 4.

A. Framework of cage before covering.
B. Windbroken white spruce; a major factor in the increase of the spruce bark-beetle.
C. Cages constructed for life-history studies.

PLATE I.

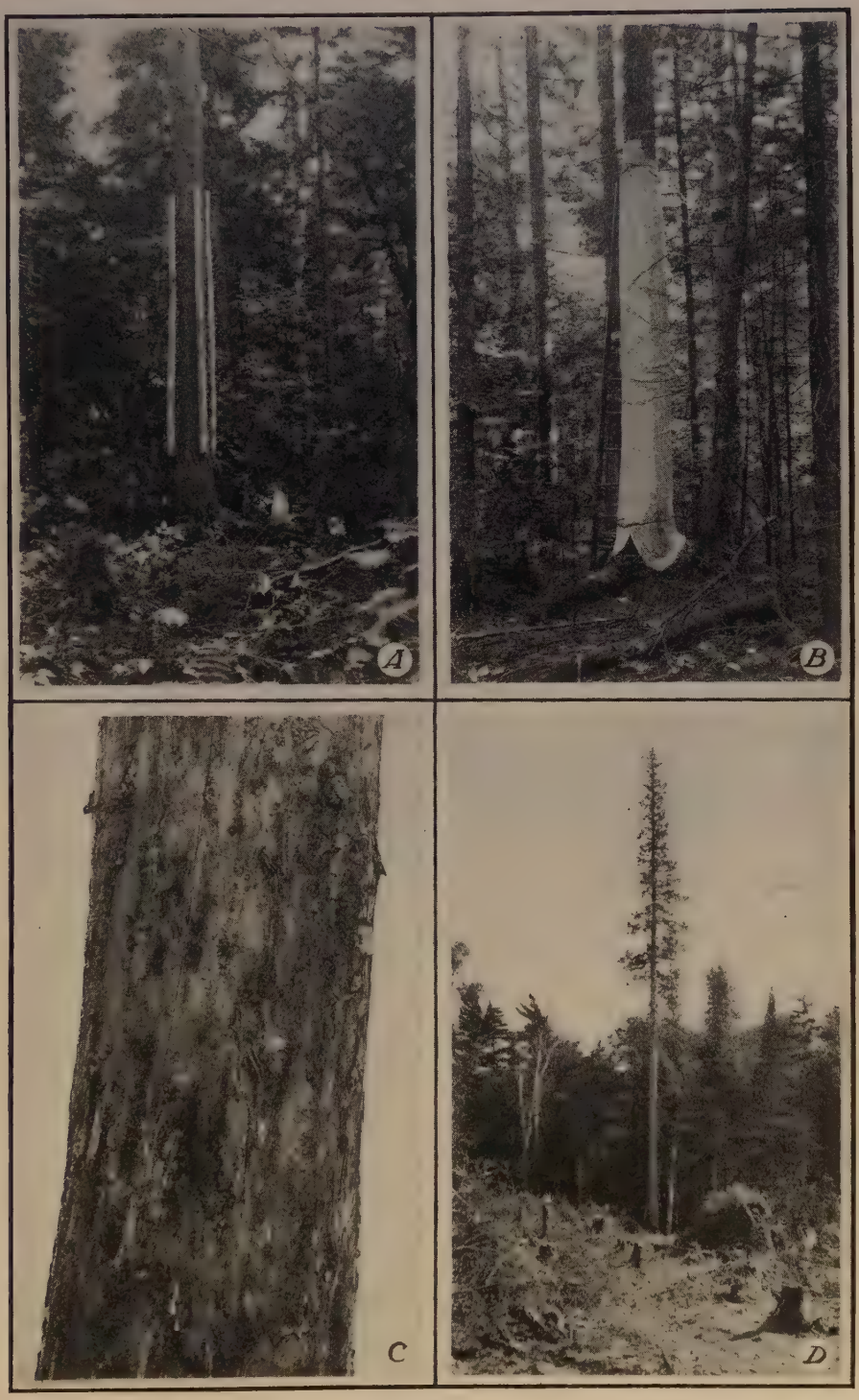


PLATE II.

PLATE III.

PLATE IV.

SOME OBSERVATIONS ON PHYSIOLOGICAL DISEASES IN APPLE IN BRITISH COLUMBIA*

H. R. McLarty†

[Received for publicaton May 7, 1928]

In the spring of 1922, there was undertaken by this laboratory as a major project, an investigation of certain physiological diseases in apple trees. In the annual reports submitted since to the Dominion Botanist, only brief mention has been made of this investigation and results were presented of only some phases of it. It is now felt that a more extended account of this investigation may prove of interest. Though by no means complete, we are at least in a position to record a series of facts with regard to the occurrence of these phenomena which throws considerable light on their probable cause.

Of these troubles, which we regard as physiological in nature, and which are common in this section of British Columbia, there occur three distinct types on the apple in which we have been particularly interested. These are, calling them by their local names,—Die-back, Drought Spot, and Corky Core.

By the term Die-back, there is not meant that type of injury which results from a direct killing by heavy winter frosts and which is characterized by a browning of the cambium immediately after the frost occurs. Rather the Die-back, in which we are interested, and the type which is far more common here, is characterized by the apparent inability of the tree to put out normally its buds on last year's terminal growth, or by its tendency to put out a sickly cluster of leaves that soon shrivel and die, the bark and the cambium being at the same time in apparently healthy condition, with death occurring in these tissues only later in the year.

By Drought Spot, we mean that condition of the fruit which results from a dying of the epidermal layers of the fruit at a time when the apple has just passed the blossoming period. The amount of tissue killed varies greatly in different apples and in different seasons, and, as a result, there are produced apples showing various degrees of injury. When the killing is extremely slight, there are produced apples having only a slightly russeted appearance around the calyx. When the injury is more severe, we find apples showing many depressions and at the base of each depression is found dead corky tissue. This type of apple, in the early stage, often exudes drops of ooze. When the killing on the surface is severe, that is, when several of the outer layers of cells are killed, the resulting apples remain small, are severely cracked, and absolutely worthless for the market.

By Corky Core, we refer to that condition of the fruit in which light brown spots of dead corky tissue occur in the region of the core, sometimes involving the whole flesh of the fruit. These spots appear throughout a

*Contribution from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa.

†The writer desires to express his sincere appreciation of the valued assistance given by the members of the Provincial Inspection Service and his thanks to the growers in whose orchards the work has been carried on.

FIGURE 1. Two trees showing Die-back brought about by super-drought conditions. The one on the left is making fair recovery—the one on the right is so badly affected that it will die.

considerable period during the development of the fruit, but are usually not found until the apple is about half grown. The spots can continue to appear from that time on until the fruit is picked, but they do not develop further in storage. No evidence of this trouble is apparent from the exterior, and it is only by cutting into the fruit that the diseased condition can be found.

PREVALENCE OF THESE PHENOMENA

This group of diseases causes more economic loss to the apple industry of the Okanagan than does possibly any other. Their severity varies greatly from year to year, and it is difficult to get exact data on the financial loss in-

FIGURE 2. Apples affected with the severe type of Drought Spot.

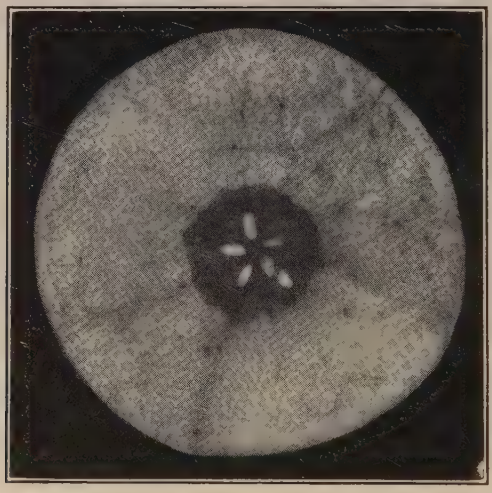


FIGURE 3. Corky-core on Jonathan. Note how the diseased area is confined to the core.

curred. By way of illustration, however, a few examples might be cited. In the spring of 1927, a five acre block of McIntosh trees was practically wiped out by the Die-back condition. In this case, the injury was so severe that the limbs, as well as the twigs, were affected and the trees produced only a few sickly shoots which sprouted out around the lower branches near the trunk. It is interesting to note that last year these trees bore a crop of "corky core" apples, but when examined in the winter, appeared to be in a fairly healthy condition.

For the Drought Spot condition reference might be made to one ten-acre block which has not produced a commercially paying crop in the last four years. The trees have blossomed well, have set fruit in abundance, but the fruit has been so affected with Drought Spot that it has been worthless for the market. Many more examples, such as this, can be cited.

Losses incurred through the Corky Core condition might be illustrated by the Salmon Arm situation in the fall of 1922. (Fig. 4). Out of an estimated crop of 120,000 boxes enough fruit remained on the trees to fill 60,000 to 80,000 boxes that were not worth picking.

FIGURE 4. Orchard showing very severe losses from Corky Core. Note the apples on the ground. The crop was a total loss.

INVESTIGATIONAL WORK

In starting an investigation of these diseases, it was at once apparent that the three types seemed to be in some way associated; trees susceptible to one showed a susceptibility to the others. For example, a tree might have Drought Spot one year, Corky Core the next, and Die-back the year after. It is true that sometimes a tree appears to be subject to only one of these diseases, in which case the trouble is usually Corky Core. The tendency is, however, for a tree to vary from one to the other throughout a period of years, or even, at times, to have two or all of the diseases concurrently. Realizing, however, that Corky Core has been the one that has caused the greatest amount of loss, primary attention has been paid to it. In our project, however, the three diseases are being considered as a group, since the causes appear to be in some way associated.

While there existed every evidence from observation that these diseases were physiological in nature, nevertheless, as an initial and precautionary step, a careful search was made for any pathogenic organism in the diseased tissues. Following the most approved methods, exhaustive series of isolations have been faithfully made, but all efforts to isolate pathogenic organisms have

proved utterly futile. This failure served to emphasize the suspicion that we were confronted by purely physiological problems, and our plans of attack were laid accordingly.

Furthermore, since we knew little concerning the cause of the disease, our plan of attack had to be of a fundamental character. We laid out, therefore, a broad field of operation, and hoped, by a process of elimination, by comparison, to arrive at a clue indicating the cause. While, perhaps, our reach has exceeded our grasp, we have, however, maintained, throughout five years, the same general plan and hope, later, to deal with the details, which, for the time being, have been allowed to remain unattended to.

In general, we proposed two main fields of activity. We desired, first, to learn whether or not the use of certain cultural methods would prevent the re-occurrence of these diseases; and second, to ascertain, if possible, whether there was any outstanding difference in the factors influencing growth, between orchards affected with, and those free from the disease.

A. Influence of Cultural Conditions

To test the influence of cultural methods, a plot of ground, of approximately 2 acres extent, of uniform slope and soil, and planted to Wealthy apple trees, was taken over. The plot was divided into sub-plots, of 16 trees each, and on each a different cultural method was applied. These cultural methods were:— Plot No. 1, a cover crop of vetch with the addition of water; Plot No. 2, clean cultivation with manure and water; Plot No. 3, clean cultivation and water; Plot No. 4, clean cultivation and manure. Only sufficient water was added to avoid, as we thought, injury to the trees through drought. The amount of water applied was accurately measured, and the resulting influence recorded by soil moisture determinations. Soil samples were collected from each plot, at weekly intervals, at a 15 inch level.

This experiment was begun in the spring of 1923 on a plot of ground situated in the Salmon Arm district. In this region irrigation is not practised. For our plots, however, sufficient water was procured from the town water supply. The manured plots received one application each spring at the rate of 16 tons per acre.

The season previous to the taking over of this plot, the district of Salmon Arm generally was very badly affected with Corky Core, and the area taken over for investigation was uniformly and severely affected. We were not able to obtain a check plot exactly comparable in all respects to the treated plots. The one chosen was in the same orchard, but the soil was of slightly different type from that of the experimental plots. In checking the results, therefore, of the experiments we have not only made observations on the check plots but on the district in general.

It is difficult to attempt the tabulation of the results obtained on a disease expressing such wide variation in severity as Corky Core. The table shows for example, especially in the year 1926, a fairly severe occurrence of the disease in plot No. 1. As a matter of fact, the disease, though present in five trees, was so slight that the whole crop from the plot was marketed in the usual

	Amount of Corky Core	Amount of Irrigation in acre inches
1923	Plot No. 1 None	4.54
	Plot No. 2 None	1.56
	Plot No. 3 None	1.56
	Plot No. 4 1 tree affected slightly	
	Check District slightly affected.	
1924	Plot No. 1 None	12.79
	Plot No. 2 None	3.89
	Plot No. 3 None	5.64
	Plot No. 4 1 tree affected	
	Check fairly severe.	
	District not severe	
1925	Plot No. 1 1 side of 1 tree	17.7
	Plot No. 2 15 trees affected	6.3
	Plot No. 3 5 " "	7.32
	Plot No. 4 13 " "	
	Check badly affected	
	District severe	
1926	Plot No. 1 5 trees slight evidence	3.6
	Plot No. 2 13 trees	3.6
	Plot No. 3 12 "	3.6
	Plot No. 4 12 "	
	Check 4 "	
	District quite severe	
1927	Plot No. 1 2 trees	3.6
	Plot No. 2 5 "	3.6
	Plot No. 3 1 "	3.6
	Plot No. 4 5 "	
	Check 3 "	
	Not severe in district	

manner. The results of these experiments over a five-year period show, first, that the cultural practices have a marked effect on the occurrence of the disease, and, second, that the disease responds to control from a commercial viewpoint, in the Salmon Arm district at least, by the use of a vetch cover crop, with the addition of water.

B. Investigation of Factors Influencing Growth in Healthy and Diseased Orchards

The second phase of our attack on the problem was to ascertain, if possible, whether or not there was any outstanding difference in the factors influencing growth, between orchards affected with, and those free from the disease. It so happens that these diseases often occur on trees growing under apparently identical conditions of environment with healthy trees in their immediate proximity. In fact, it sometimes happens that the symptoms may exist on only one branch of a tree which otherwise produces healthy fruit. The occurrence or non-occurrence of these diseases on trees growing under apparently similar conditions suggested to us that there might exist only some small difference in environment, which was responsible for the trouble; a difference which we might be able to determine from intensive study.

It was therefore considered necessary that observations be made in eight plots, situated in four different districts. In each district, a suitable plot free from the disease and a susceptible one, were to be chosen. The plots were to be situated in separated districts, firstly—in order that more growers might be attracted to follow our efforts, especially if valuable, worth-while results were obtained; secondly—in order to obtain a higher degree of certainty of having the disease occur in at least one of the plots each year, as it was felt that variation in climate and water supply would greatly heighten the probability of its occurrence.

The plots have been located as follows:—Kelowna 2, Glenmore 2, Westbank 2, and Summerland 2. Since 1926, however, for the Westbank and Summerland plots there have been substituted plots in the Winfield district. The size of plot chosen in each district was an area in which were growing four trees of similar variety, age, and vigour. This rather limited size of plot was due to the difficulty of locating larger areas with uniform soil conditions. The two plots chosen in each district were as similar in all respects as regards type of soil, age, variety, and vigour of trees as it was possible to obtain. The growers interested have cooperated in allowing free use of their orchards for the obtaining of all experimental data, for which we desire here to express our sincere appreciation.

The project was then divided into three main divisions, first—to investigate soil conditions in a healthy and in a diseased orchard; second—to investigate air conditions in a healthy and in a diseased orchard; third, to study conditions in the trees themselves from every angle.

Investigation of Soil Conditions in Healthy and Diseased Orchards

Observations were made in each orchard on the following:—

(a) Depth of soil.
(b) Kind of soil, determined by laboratory tests.
(c) Physical condition of the soil throughout the season, observations being made each week.
(d) Cultural practices in the orchard.
(e) Effect of fertilizers.
(f) Soil moisture, samples being collected each week.

2. Air Conditions in Healthy and Diseased Orchards

It was soon recognized that to obtain all meteorological data from each orchard, which might have an influence on the problem, was beyond our ability; nevertheless, it was considered necessary to have information on certain conditions that bear directly and markedly on the metabolism of the tree. It was therefore proposed:—to obtain daily maximum and minimum temperatures, to obtain records of high winds from observations of the grower and from the meteorological branch of the Summerland Station; and—essentially so—to obtain the amount of weekly evaporation in each orchard as recorded by the Livingstone atmometers.

3. A Study of Conditions in the Trees Themselves

It was hoped that, by making as many observations as possible on healthy and diseased trees, we might gain useful information indicating possible causes for the trouble. Observations were made and records kept on:

(a) Vigour of the trees as expressed by leaf size, colour, the amount of terminal growth, and the colour of the bark.
(b) Age of tree.
(c) Crop—1. Thinning practices. 2. Amount of crop.
(d) Colour and texture of fruit.
(e) Pruning methods.
(f) Winter injury.
(g) Storage qualities.
(h) Varieties affected.
(i) Growth measurements of individual fruits.
(j) Root development.

RESULTS

1. Soil Conditions

(a) *Depth of soil*

These diseases are present on shallow soils, medium deep soils, and on very deep soils. We have also found healthy trees growing on soils of similar depths. There is to be found, however, a higher percentage of susceptible trees in shallow soils and in deep poorly drained soils. While susceptibility to the disease does vary thus in different depths of soil, the occurrence of healthy trees under these conditions would make it appear that depth of soil of itself is not a contributing factor. Apparently, then, there is no varying factor here responsible.

(b) *Kind of soil.*

We have found the disease on gravelly soils, sandy soils, loams, silts, and in clay. We have also found healthy trees growing under these same conditions. We have found, however, that trees growing in sand and gravelly soils, and in silt and clay soils, *where drainage was poor,* have a greater tendency to become diseased, than those growing in a good deep loam. In fact, it has been rare for us to find diseased trees in good, deep, loamy soils. They have been found there, but not often. Thus it seems indicated that the kind of soil is in some way associated with the disease, but here again the occurrence of healthy trees under the same conditions shows us that these conditions in themselves are not solely responsible factors.

(c) *Physical condition*

Where physical condition is poor and the soil cakes easily and becomes very hard, or where the physical condition is such that a hard pan occurs a short distance below the surface, we find a higher susceptibility.

(d) *Cultural conditions*

So far as we have been able to observe, the cultural method employed in an orchard is not in itself an important factor in producing these diseases. We have found both healthy and diseased orchards under all the commonly used

cultural practices. We have observed, however, that a changing over from one cultural practice to another does seem to influence susceptibility to these diseases. For example, we know of one orchard where the changing over from a cover crop to clean cultivation reduced the amount of disease. We know of another orchard where the planting of a cover crop of vetch in place of former clean cultivation lessened the amount of disease. We know of still another orchard where the putting in of a cover crop of alfalfa on former clean cultivation greatly increased the amount of disease. We have also found these diseases in orchards which have been totally neglected for as much as eight years or more.

(e) *Effect of fertilizers*

In general, good humus content in a soil, providing the latter is of reasonable depth, is apparently a protection against the disease, for we rarely find it occurring under such conditions. When trees, however, are growing under conditions where either the depth of soil or the openness of the soil combine with inadequate water supply to the degree of being a limiting factor for good root growth, then any sudden increase in the food supply of the tree which will induce rapid growth during the early part of the season, has a tendency to produce or increase the disease. That is, in a district such as Salmon Arm, where even though we have a fair depth and texture of soil, but a great lack of sufficient moisture in dry summers and falls, we can greatly increase the amount of disease by heavy applications of manure or nitrate of soda. Trees so treated increase greatly in terminal growth and improve greatly in colour of foliage. Corky Core and Drought Spot, however, have been increased greatly in these same trees and, in one case, even Die-back has been promoted.

(f) *Soil moisture*

The amount of soil moisture present in the orchards used in this investigation was determined by laboratory tests of soil samples collected each week. The samples were taken usually from a 15 inch level, as we found at this depth that we received the best average of the soil moisture around the majority of the feeding roots of the tree. Moreover, they were taken at a constant distance from the irrigation furrow.

We expected to find an excessively dry condition of the soil associated in some way with the simultaneous appearance of the disease. This, however, was not the case, as at the actual time of the appearance of the disease, soil moisture conditions around diseased trees are often of the most favourable character. While we have found the disease occurring on trees where the soil moisture drops low during this period, we have so commonly found the other condition that we have rejected the idea that low moisture content is a responsible factor during this period. Moreover, we have observed that low moisture content may prevail at this period even to the extent of a wilting of the fruit, and yet no disease be produced.

On the other hand, we do find a very definite relationship between soil moisture and the occurrence of the disease, but we find the unfavourable soil moisture; whether it be super-dry, or super-wet, occurring around trees in the late summer and fall previous to the season that the disease actually appears

in the tree. That is, we find greater susceptibility in orchards where they either become very much dried out in the late summer or fall, or where the soil becomes water-logged during that same period.

2. Air Conditions in Healthy and Diseased Orchards

When the investigation was started, it was hoped that daily maximum and minimum temperatures could be procured in each orchard under test; also, that humidity and wind velocity could be recorded. It was impossible, owing to the distance of the orchards from the laboratory, to obtain these ourselves, and we found that it was very difficult to get the growers to take them satisfactorily. We have had, therefore, to rely on the nearest official recording station for our climatic conditions, and on our own observations made at the time of the weekly visit.

From these, we have found no one individual factor which might seem to produce the disease. The air conditions, so far as we could learn, were identical around both healthy and diseased trees.

3. A Study of the Conditions in the Trees Themselves

(a) *Vigour, as expressed by the size and colour of leaf, the amount of terminal growth, and the colour of the bark.*

We found that trees could have excellent vigour, yet be badly affected with Drought Spot and Corky Core. Trees showing Die-back were affected in their vigour, though many of such trees made wonderful recoveries during the growing season. Some of the apparently best foliage may be found on trees having Drought Spot and Corky Core very badly.

(b) *Age of tree*

We have naturally found the disease on trees just coming into bearing as well as on trees of any age after that time.

(c) *Crop*

1. Thinning.

The disease occurs on trees which have been thinned heavily, thinned lightly, and not thinned at all.

2. Amount of crop.

We have found Drought Spot and Corky Core on trees where there were only a few apples on the whole tree; again, when the trees have been loaded to the ground; and on all intermediate stages.

(d) *Colour and texture of the fruit*

It is believed by many that Corky Core apples may be detected on a tree by their higher colour and by a certain feeling of the fruit when gripped in the hand. We have not been able to verify either of these suppositions. Sometimes Corky Core fruit does appear to be of higher colour than fruit on nearly healthy trees. On the other hand we often find Corky Core apples quite off shade and distinctly under coloured. Tests carried out on gripping the apple have given about 50 per cent error.

(e) *Pruning methods*

While no definite pruning experiment has been carried out, we have had ample opportunity to study the effects of different amounts of pruning. For example, certain trees, in our experimental plots, were heavily pruned because of the Die-back condition; nevertheless, those trees continued to be affected with one or other of these three diseases. On the other hand, where no pruning whatever was practised, as in neglected orchards, the disease was also found. Pruning, as ordinarily carried out, has no apparent influence on the occurrence of the trouble.

(f) *Winter injury*

It was believed for a time that these diseases were associated with some type of winter injury. So far as Corky Core is concerned, we had an excellent opportunity, during the winter of 1924-1925 and the following summer, to study the effect of winter root killing on the production of this disease.

Casual examinations of trees early in the spring of 1925 disclosed the fact that there had occurred, very generally, an exceedingly severe killing of the small-root systems. Since there was thought to be a definite relationship between this type of winter killing and the occurrence of one or more of these diseases, it was thought advisable to carry out a fairly extensive examination. Accordingly, the root injury on 114 trees located in different districts was estimated by digging 4 holes 2 feet deep around each tree and recording the amount of killing on the roots so exposed. This examination showed that a very severe killing did take place, chiefly on the small roots and rootlets of the trees. In some cases no sound roots less than one-half inch in diameter could be found within 2 feet of the surface of the ground. Such a killing removed, in many cases, 90 to 95 per cent of the absorbing root surface of the tree. A later examination of the fruit on these trees made by cutting apples on limbs directly above the position where holes had been dug showed no evidence of a relationship between the amount of this type of root killing and the occurrence of the disease.

(g) *Storage qualities*

During three seasons a fairly extensive series of storage tests have been made on apples affected with Corky Core. These tests have been made under both common and cold storage conditions. We have found first—that the disease does not develop in storage, and second—that affected apples do not appear to be more susceptible to breakdown or storage rots.

(h) *Varieties affected*

While we have found no variety altogether immune from these diseases, we have found that some varieties are more susceptible than others. The important commercial varieties worst affected, in their order of susceptibility are as follows:—McIntosh, Wealthy, Jonathan, and Rome Beauty.

(i) *Growth of individual fruit*

In this study it was hoped to find some difference in the way a diseased and a healthy apple grew in size. We were of the opinion that the dying of the cells in the case of Corky Core was brought about by lack of moisture

in the fruit. There ought to be, we thought, some evidence of this desiccation in the growing apple. To test this point, we developed an apple-measuring machine which records on a chart the daily increase or decrease in size. The photographs show the nature of the chart it produces. (Figs. 5 and 6). Diseased and healthy apples have been measured by these machines, but we

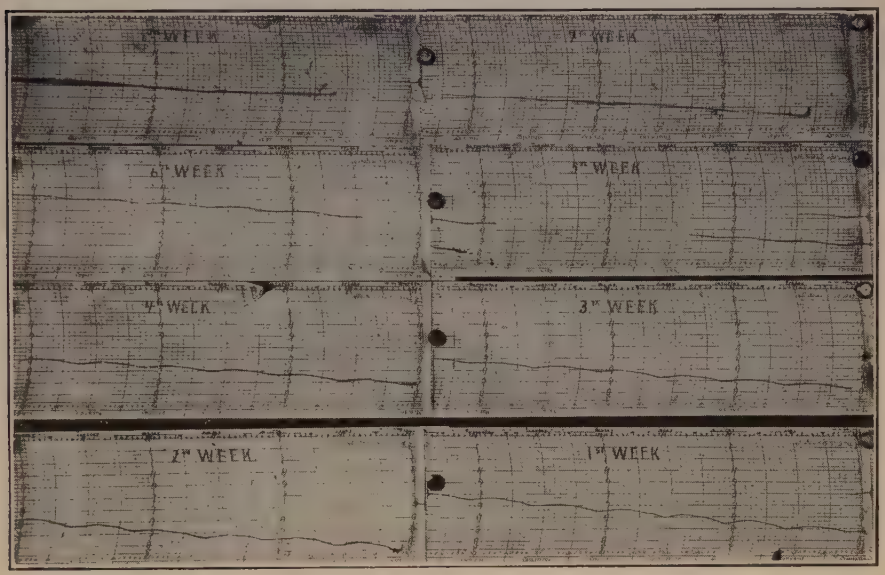


FIGURE 5. Graph of an apple which did not develop Corky Core, but which came from a tree on which Corky Core occurred. Note the shrinkage that can occur on a growing apple.

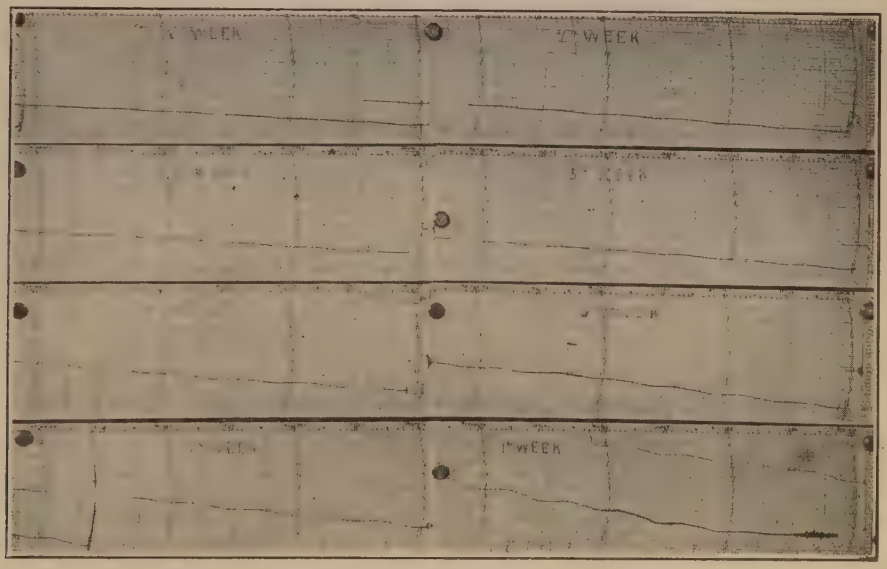


FIGURE 6. Graph of an apple which developed Corky Core. Note the fluctuation in growth between night and day. Growth takes place between 6 o'clock at night and 9 o'clock in the morning.

find no marked difference in the way they grow. The charts indicate that both susceptible and healthy apples show a distinct fluctuation in growth between day and night. This fluctuation is especially marked when the apple is small and decreases gradually with the increase in the apple's size. The chart shows that rapid growth takes place at night while there is practically no increase in size during the day. Sometimes there is shown to be even a shrinkage during the day, this shrinkage occurring in both diseased and healthy fruit.

(j) *Root Development*

When this investigation was begun, we had the idea that the injury in the fruit was associated with very dry soil conditions prevailing at the time the injury appeared. We reasoned that, by making a root study, we might be able to demonstrate the occurrence of a plasmolysis of the root hairs and young rootlets at the time or just previous to the time the injury occurred in the fruit.

We did not find anything of this nature occurring. Root development was commonly as vigorous and rapid in diseased trees as on a normal tree at the very time that one or other of the diseases was making its appearance. The continued study of root development on both diseased and healthy trees, throughout the whole growing season, however, has shown that there is a period at which a distinct difference is apparent in the rootlet development in the two classes of trees. This period occurs during the late summer and fall, at which time soil moistures are often allowed to run low in the orchards. We have found that a killing of the root hairs and succulent rootlets occurs at this time whenever the soil moisture approaches the wilting co-efficient. (Figs. 7 and 8). Some rootlet killing of this nature occurs on many trees

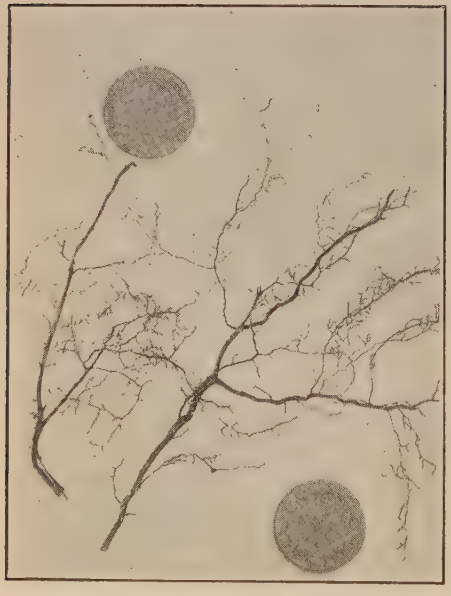


FIGURE 7. Roots from a diseased tree showing the type of killing brought about by super-drought conditions.

FIGURES 8. Rootlets from a healthy tree showing normal root development. Compare this with Figure 7.

some of which, in the following season, prove healthy and others diseased, but the percentage of rootlet killing is much greater on the trees which show the disease during the following season than it is on the trees that are healthy. For example, in a comparison between two neighboring trees, one healthy and one diseased, on the diseased tree (which had Die-back the next season) we could not discover any live rootlets in October, whereas on the healthy tree, though many dead rootlets were found, here and there we also observed many live root tips which were apparently functioning in a normal manner. In such examinations, of course, only sample rootlets were examined from each tree; it is not inferred that the trees were removed for examination. This relationship between the percentage of live and dead rootlets on healthy and on diseased trees has been verified many times in many orchards under all kinds of conditions previously referred to.

The possibility, that excessive rootlet killing at this period was responsible for the disease where excessive drought occurs, suggested the idea that it was also rootlet killing which produced the disease under excessive moisture conditions. A study of rootlets which suddenly become exposed to conditions of super-moisture convinces us that an excessive rootlet killing here also does take place.

It would seem, therefore, in our study up to the present, that the responsible factor is the sudden killing off of too high a percentage of absorbing rootlets during the late summer and fall previous to the season when the disease appears in the fruit.

Discussion

The discovery of this excessive root killing at this period in the seasonal growth of the apple tree, and its relationship to the occurrence of the disease have led to the development of a hypothesis as to the cause of the disease. It is briefly presented here, not with the idea that it is yet thoroughly established, but that it seems to offer a reasonable explanation for the occurrence of these three types of phenomena.

We have evidence to believe that, as a result of this sudden killing off of an excessively high percentage of the absorbing system of the whole tree, or even of only one main root*, there results a lack in balance in the manufacture of the food in the tissues of the tree or in the limb above the affected root area. If this lack of balance in the food supply exceeds the degree of tolerance allowed by nature for normal development, it produces—in the protoplasm of the developing buds, which during that time are just in the formative period,—a pathological condition, from which, during the later development, they are unable to recover, even though the food supply during this later development may be ample and normal. In other words it is useless to feed any living organism an abundance of food which it is unable to absorb.

*E. C. Auchter, University of Maryland, Agricultural Experiment Station—Bulletin 257—September, 1923, has shown that the mineral nutrients absorbed by the roots on one side of a tree are in a large measure translocated to and used by the trunk and leaves directly above them. There is apparently very little cross transfer of such nutrients in the plant.

Furthermore, this unbalanced food supply so affects the protoplasm in the young buds in their formative period that there occurs a fundamental change in the protoplasm itself—a change so inherent that it reproduces that condition, whatever it may be, in all the cells subsequently laid down from these primary ones so affected. The evidence of the resulting weakness in the protoplasm, however, is not apparent at the time, and is expressed only when the fruit passes through any unfavourable physiological condition in its later development. That fruit, in its development, does pass through such periods of strain, has been shown by the automatic apple-measuring machines which have been used in this investigation. These have demonstrated that the apple has a distinct, daily fluctuation in growth, especially in the earlier stages of development. We find that an apple, under our climatic conditions, grows almost wholly during the night, while during the day, there is little or no enlargement and often, even, a shrinkage.

This arresting of the growth or the production of a shrinkage is thought to be brought about by the rapid transpiration of moisture by the leaves. The loss of moisture is so rapid, under certain conditions of temperature, humidity, and wind that, even in normal trees, the supply cannot be kept up by the roots; as a result, moisture is entirely withheld from the developing fruit, or it may be withdrawn from the fruit and cause a shrinkage. When such conditions arise as to arrest development completely we believe these cells are put under more or less of a physiological strain. To this strain, cells of both healthy and diseased apples are subjected. Those which are healthy withstand it; those which carry this inherent weakness are unable to do so and succumb. Thus it would seem that the apple is subject, during its initial stages of growth, to certain inherent weaknesses that later express themselves more formidably in a condition which we, somewhat loosely, have come to regard as a disease. The final mode of expression of this weakened condition, whether it takes the form of Corky Core, Drought Spot, or Die-back, is, as we finally hope to prove, dependent upon either a variation in the severity of the unbalanced conditions or upon the time at which these occur, as well as the duration of that period.

Just what degree of inherent susceptibility, if any, to other of our physiological diseases is carried over in apples and in other fruits will have to be established by further experimental work. It appears, however, in the light of this theory, that the susceptibility to such common diseases as Breakdown and Bitter Pit in apples, russetting on apricots, gum-spot on prunes, excessive stone formation in the outer layers of the pear, and a sunken spot condition on peach and plum might become inherent in the fall previous to the season in which the disease actually occurs on the trees. In conclusion I desire to express my grateful thanks to the Dominion Botanist, Mr. H. T. Güssow, for suggesting this phase of research as the most outstanding one requiring immediate attention in the Okanagan valley, and for his helpful advice and criticism, especially in regard to the presentation of these data.

Dominion Laboratory of Plant Pathology,
Summerland, B.C.

DIVERSITY OF SOIL TYPE IN THE PRAIRIE PROVINCES AND CAUSES OF THE SAME*

A. H. Joel

The Saskatchewan Soil Survey, conducted during the past five summers and covering a road mileage of approximately 40,000 miles, has enabled the soil survey party to study soils, natural vegetation and agricultural practices over much of the province. Furthermore, discussions with soil authorities from Manitoba and Alberta have permitted a general correlation of such observations with similar investigations made in these sister provinces.

Diversity of Soil Types

One very definite impression, as the result of our survey studies, is the great diversity of soil groups and soil types and consequently of the agricultural suitability of regions and districts of the province. The habit which a soil surveyor develops, of seeing and thinking in terms of soil character, natural vegetation and agricultural adaptations and practice, sharpens this impression greatly. This is especially true when one goes into widely separated areas in the same season. Natural vegetation is a fairly good indication of agricultural possibilities. One finds in Saskatchewan plants common to the desert and others common to humid regions of eastern United States and Canada. Such exceptional plants, however, are practically never found in the same locality but are usually widely separated in the province.

Another impression, or rather, strong realization, is that a large proportion of our farmers and others as well do not realize this fact of diversity. As a result the majority follow the general system of agriculture which has become fairly orthodox for the province, and almost completely disregard the peculiar conditions which locally influence the suitability of their lands to this or that agricultural practice. For example, there are thousands of acres of land unsuited to the production of Marquis wheat and far better adapted to other grains or to live stock production, and yet one sees farmers trying for years to grow this crop. They usually get about one crop in six, or even less. Examples could be given of the ill adaptation of other crops, of cultivation practices and of general farming systems, but most of these are obvious, True, our agriculture is hardly out of the pioneer stage, and we should not expect too much from our comparatively short period of development. Nevertheless, the fact remains that the fault exists, and we hope that if our soil survey accomplishes nothing else, it will at least awaken a realization that within the confines of our provincial boundaries there exists far greater variation in soil, climate, natural vegetation and agricultural suitability and related conditions than in many whole countries.

Soil Genesis

The primary aim of this paper is to point out the causative or genetical factors which are apparently largely responsible for determining the character

*From a paper presented to the meeting of Dominion and Provincial Agricultural Investigators held at Saskatoon, February 1, 1928.

of our soils; and to correlate variations in soils with specific genetical factors or combinations of such factors which produce them.

Environment and Geological Origin

Investigations of the past quarter century indicate that soils are products of combinations of environmental factors acting on a given parent or original, geological material. As a corollary to this we may also state that soil nature expresses the particular environment in which it has existed for a long period of time. The length of time during which the particular environment has acted on a given soil determines the particular stage of development and is therefore also a factor in determining soil nature. Thus we have a certain normal type

A deep black soil of the park belt shown in the profile of the Oxbow Loam type. The lime layer occurs here usually at a depth of about 16 inches. The depth and nature of the lime layer reveals much as to the regional climate conditions over a long period of time.

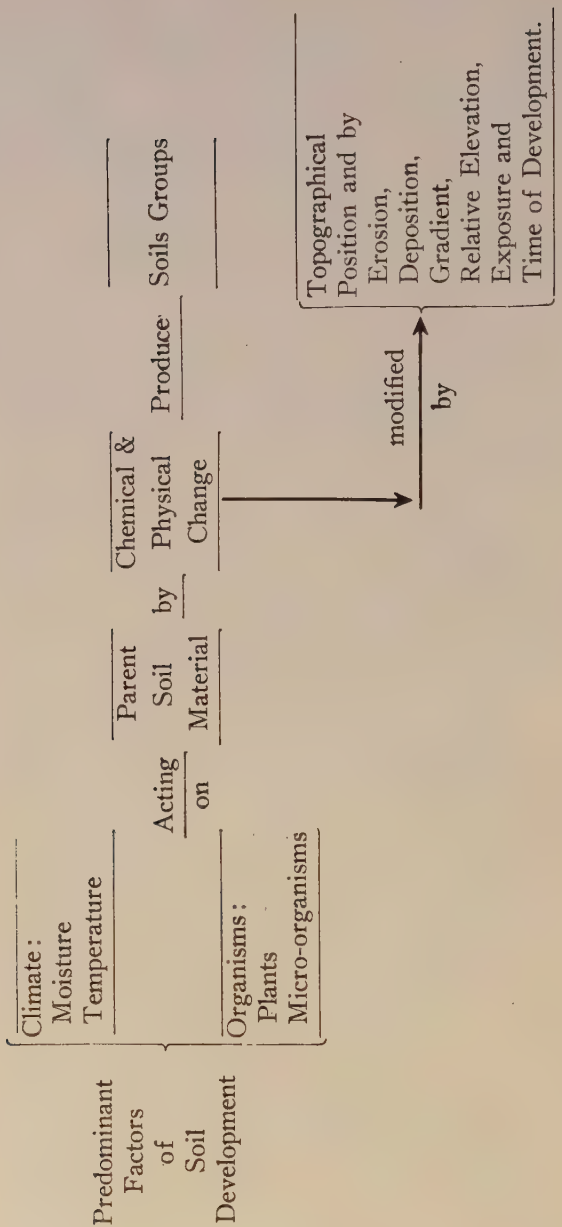
of development of soil for each particular environment from an original geological deposit and we also have different stages of such development dependent on their age. This at least is the generally accepted conception of soil scientists and there seems to be plenty of evidence to bear this out. In fact, given certain data as to natural environment, one can predict, with surprising accuracy, the general groups of soil which occur in almost any part of the world.

By environment we mean such factors as temperature, precipitation, evaporation, natural vegetation, soil micro-organisms, topographic position, etc. Combinations of these and other unmentioned factors acting physically and chemically on a given geological deposit, produce a certain type of soil for the locality. The activities are principally those of weathering and accumulation of organic residues. These physical and chemical changes in the soil will vary in nature and intensity with the various environmental combinations existing. The general tendency is toward simplification or dissolution of mineral and organic constituents and the accumulation of resulting products in certain soil levels as a result of transfer from other soil levels. The medium of transfer is capillary and gravity soil moisture. The result of differences in such simplification, transfer and accumulation, at various soil levels, is the formation of natural horizons or layers of soil in order of depth. Specific types of such layering or soil profiles have been correlated with particular environments, so that modern soil science considers soils in terms of particular profiles and their environmental associations.

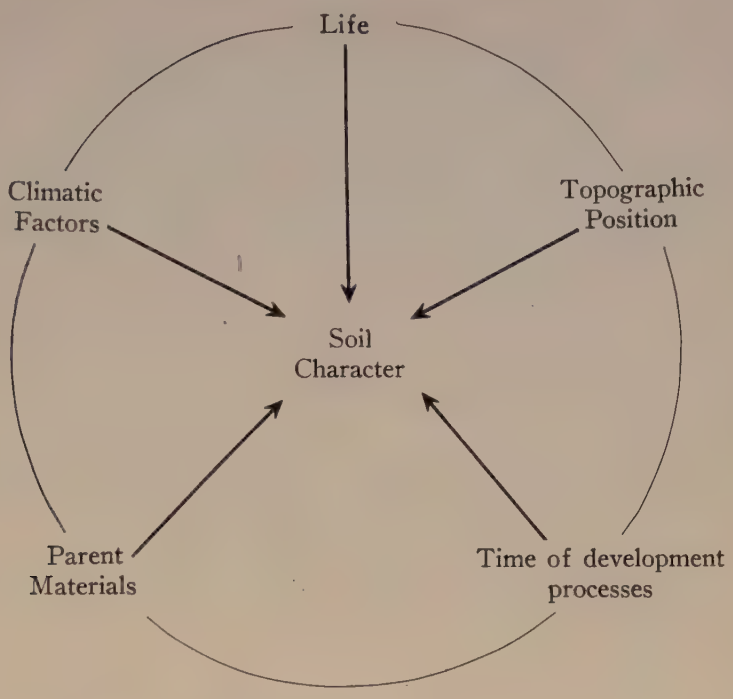
Natural Vegetation and Soil Genesis

As natural vegetation so profoundly influences soil development, and therefore the types of soil now existent, a few observations as to the nature of this influence should not be amiss at this time. Natural vegetation is also of prime importance as a genetic factor of soil development. The influence of vegetation on the prairie and plains soils is largely in the amount and depth of accumulation of organic matter, especially humified forms, resulting largely from residues of grass roots. The influence of a timber cover is largely in the cooling and moistening effect of forest shade and forest litter and the comparative exclusion of air from the mineral soil beneath the forest litter. Under such a cover of vegetation there is little accumulation of organic matter from grass roots. Rather there is a moist, partially decomposed cover of humic litter over the mineral soil. Through this humus cover much moisture filters and accumulates organic acids. This percolating, somewhat acid solution, together with the comparative exclusion of air from the covered soil, and other conditions peculiar to a timber cover, produces a characteristic type of soil markedly different than the open lands under grass. The whitish or grayish so-called, burnt-over lands of our northern bush, such as are found in the Birch Hills, Duck Mountains and probably over much of the province north of latitude 50°, are of this type.

The following diagrammatic statements may serve well in crystallizing and summarizing these preliminary remarks on soil formation.



The second diagram is to emphasize that soil character is determined chiefly by the genetical factors given. The relative importance of each character with any given soil type might be represented by differences in the lengths of radiating lines. The interdependence or inter-relation of genetic factors themselves is indicated by connecting lines. We shall later illustrate the application of these diagrams with actual soil types.



Soil Classification

One of the immediate benefits of considerations of soil genesis is the material help given by such consideration to the matter of a rational soil classification and to an understanding of the relation of soil groups in a logical classification. By logical classification I refer to one based on soil character itself. There seems to be general agreement on the part of soil scientists at the present time that this is a more rational basis than others used in the past, based on causes (geological origin, climate, natural vegetation, crop adaptation, etc.)

In the following discussion the classification suggested is based on soil character, but at the same time correlations are pointed out between soil character and genetical factors responsible for producing differences in soil character.

The Climatic Factor and Major Soil Groups

Climate is normally the predominant factor in the development of broad soil belts and vegetation zones. The discovery of this relation is largely due to the investigations of Dukochaiev, Sibirtsev, Glinka and other Russian investigators. These men had the rare opportunity of studying soils over vast areas, whereas other investigators were usually confined within the boundaries of states and small countries where there was far less chance of noting the stamp of climate on the nature of soil development.

In Saskatchewan there appears to be a fairly well marked correlation of major soil belts with the climatic factors of precipitation, temperatures and

evaporation. A similar correlation generally holds true also for climatic and natural vegetation associations. As a result of this parallel correlation, the major soil belts and natural vegetation belts are practically identical.

We shall begin our classification, then, by outlining the great soil belts whose general character reveals the stamp of prevailing climate and natural vegetation. Most of these belts are roughly outlined on the sketch map of the Prairie Provinces. They are also listed in the following table with a brief statement of outstanding climatic features for each group.

PREDOMINANT CLIMATIC FACTOR OR FACTORS	ZONAL SOIL BELTS (Major Category)
1. Very low temperature Shallow frost line	Tundra. Bog type.
2. Low temperature; relatively high moisture*	Grey podsol or northern timber.
3. Higher temperature; less moisture	Black park.
4. Moderate temperature†; relatively moderate moisture*	Chestnut brown prairie plains
5. Moderate temperature†; low moisture*, hot winds.	Brown prairie-plains.
6. High temperature†; low moisture*, hot winds.	Greyish brown plains.

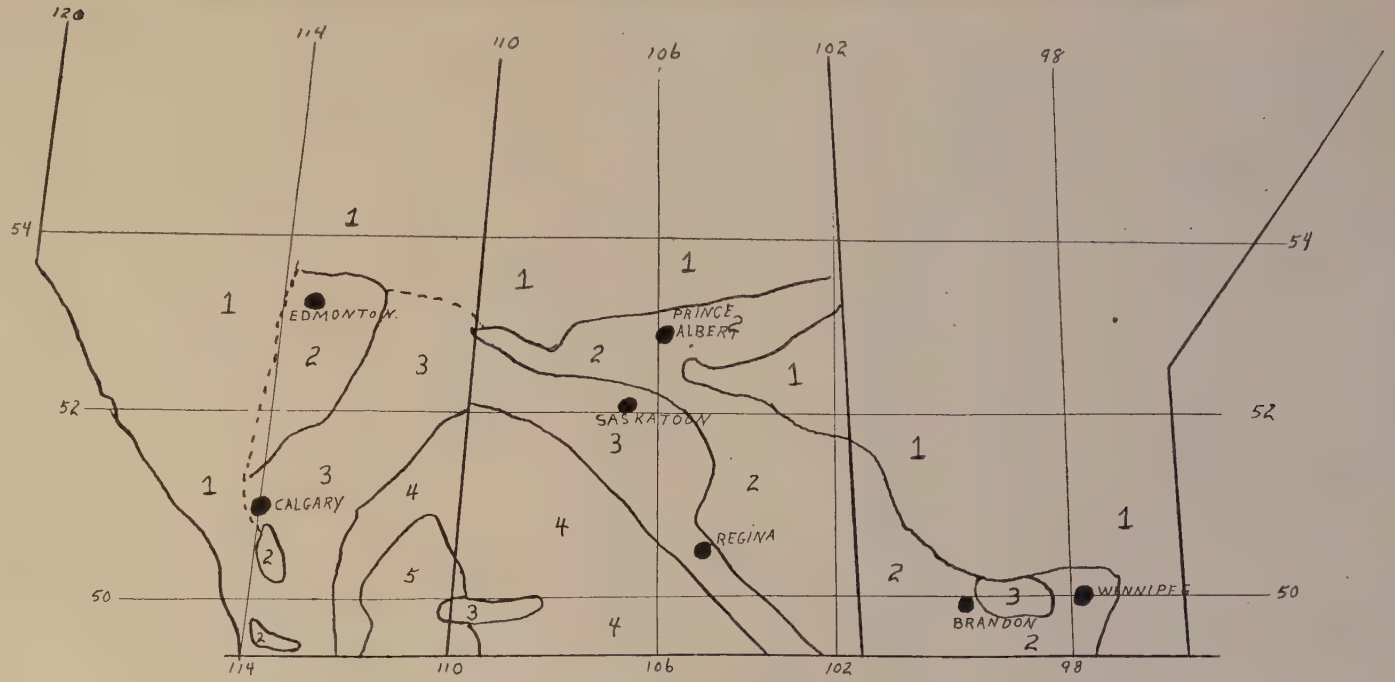
* Available soil moisture, basis of Saskatchewan conditions.
† Basis of Saskatchewan temperatures.

Except in the far north, where extremely low temperatures seem to be predominant in influence, the differences in these soil-vegetation zones seem to be caused chiefly by differences in the amount of available soil moisture. The amount of moisture will obviously influence the type of vegetation which, in turn, influences soil development. The amount of moisture will also determine the amount free to percolate through the soil which will also vitally influence the physical and chemical changes in soil and consequently the type of soil produced. The factors most influencing the amount of moisture available to soil and plants in our conditions, it seems to me, are the amount and distribution of precipitation and the amount of evaporation (determined largely by temperature, winds and atmospheric humidity, which are in turn influenced by the amount of shading and wind protection furnished by trees and shrubs).

When, therefore, one considers regional combinations of these elements of climate and vegetation in terms of quantities of available soil moisture there seems to be a definite correlation with major or zonal soil groups given.

Both latitude and altitude influence climate and therefore influence soil belts. The Rocky Mountain chain to the west is apparently the cause of the gradual decrease of moisture from the humid east in a westward direction to the base of this great mountain chain. At least climatologists make that statement. Latitude, of course, decreases temperatures northward. The influence of moisture differences from east to west is apparently greater than that of temperature, from north to south, for the soil belts run lengthwise, generally north and south from the Gulf of Mexico into Saskatchewan and

MAJOR SOIL AND NATURAL VEGETATION BELTS OF THE PRAIRIE PROVINCES.*



1. Greyish timber soils (podsols and partial podsols).
2. Black park lands (tree clumps and tall grass prairie).
3. Dark brown or chestnut brown prairie-plains.
4. Brown or chocolate plains (short and medium grasses).
5. Greyish brown, short grass plains.

*Information as to boundaries of Alberta belts furnished by Dr. F. A. Wyatt and for Manitoba by Prof. J. H. Ellis. The boundaries are necessarily very general and not very well marked in many localities.

their boundaries are fairly sharp. These great long belts swing westward in Saskatchewan and some of them begin to double back southward in Alberta. This is probably due partly to the westward swing of the mountains and partly to the increasing ratio of influence of cold-temperatures over moisture as a predominating factor of soil development in these northern regions.

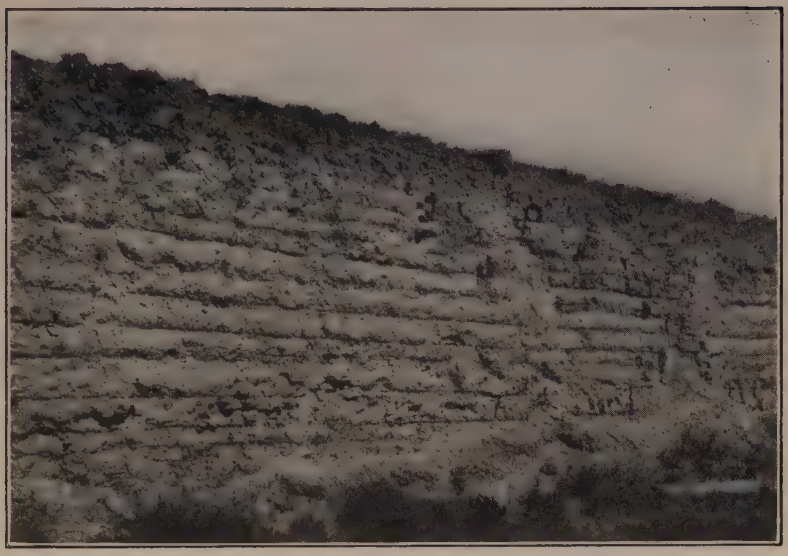
Parent Materials and District Soil Belts

In our soil survey we have noticed that parent soil materials or the surface geological formations naturally divide our major soil zones into district belts of soil with marked differentiating characteristics. It is this factor which largely determines general topography, mineral composition, soil texture, stoniness, nature of subsoils, natural drainage and similar conditions which break up the landscape into natural districts and soil areas.

The table below gives the more prevalent surface geological formations which will form the basis for our second category of soil groups. Professor Edmunds of the Department of Soils, who has been a member of our Soils Survey party during the past two summers, has made studies of the surface geology of our survey areas which have helped us considerably in our classification.

GEOLOGICAL FORMATION OF PARENT SOIL MATERIAL	PREDOMINANT TEXTURES, TOPOGRAPHY & STONINESS
Glacial	
Till plain or ground moraine	Loams, clay loams. Undulating and rolling. Somewhat to very stony.
Terminal or marginal moraines	Loams, clay loams. Strongly rolling to steep. Somewhat to very stony.
Outwash	Sandy and gravelly. Smooth, few to no stones.
Lake	Medium and heavy. Much silt. Smooth. Stone free.
Preglacial	
Deposits which weather to heavy soils	Clays and clay loams. Level to undulating. Few to no stones.
Deposits which weather to medium soils	Loams and clay loams. Few stones.
Deposits which weather to light soils	Sands and sandy loams. Few stones.
Glacial-Preglacial combination	Depending upon the particular instance.
Recent Lake deposits	Medium and heavy, silty. Smooth. Stone free.
Recent stream deposits	All textures. Smooth. Stone free.
Wind blown deposits	Sands, sand hills.

These formations are sufficiently different in minerological composition and topography to modify and influence the natural course of climatic development markedly in the climatic zone in which it occurs. Climate apparently has a greater influence on soil development than even geological origin. Some



Preglacial deposits form the parent material of a number of soil belts in Southwest Saskatchewan.

investigators even maintain that given sufficient time all soil materials in a given climatic zone will ultimately develop into the same type of soil even though of different geological origin. This theory, I believe, is rather far fetched. However, I shall not take the time to discuss this matter further. Suffice it to say that in most of our soil areas thus far surveyed the stamp of geological origin is usually sufficiently distinct to warrant the breaking up of our major soil belts either into soil series or distinct soil types.

The more or less stony glacial till plains and moraines make up most of our parent materials. At least one large glacial lake deposit exists and probably others will be outlined with further studies. Contrary to the prevalent belief, an appreciable portion of Saskatchewan has either a thin cover or no cover of glacial till, resulting in soil belts distinctly different than the till soils. In southwest Saskatchewan, especially, there are many exposures of Tertiary and older formations and a number of extensive soil belts with the unmistakable stamp of preglacial parent materials. In most of such cases the parent material is of mixed glacial and preglacial origin, resulting in soil types not found in other places in the province.

Wind blown materials, especially of the sand hill type, are fairly numerous and extensive. The Great Sand Hills and the Webb and Caron sands are good examples.

In a given major or climatic soil belt soils of similar parent materials will usually be sufficiently alike to classify in the same group. Such grouping is usually the basis for our soil series or that group in which soils may be further subdivided only on the basis of their texture; that is, on the proportions of clay, silt and sands which they contain.

Soil Texture and Soil Types

We classify our soils into soil series and soil types for purposes of mapping and description. Series, as already indicated, will usually contain soils of the same parent materials (geological origin) and in the same climatic zone. However, soils falling in such groups are frequently of different textures, as stated above. As texture exerts such a marked influence on soil character and agricultural adaptations we divide series into types which is our final and smallest unit of classification. Theoretically, soils of the same type are as nearly alike as may be determined by ordinary tests and examinations, and consequently have the same suitability for agricultural purposes. They are, of necessity, in the same climatic zone, for they could not be similar otherwise. We name our distinct soil types after the locality in which first identified. There are good reasons for using such a system and probably just as good reasons against the practice. We may change the scheme, especially in our extensive provincial soil survey, and adopt names which will be more expressive of the character of the soil type in question.

In our reports we use a textural classification used by the United States Bureau of Soils and by most soils men on this continent. This includes thirteen separate classes based on the proportions of each of seven different sizes of soil particles, viz., fine gravel, coarse sand, medium sand, fine sand, very fine sand, silt and clay. I am submitting here only five soil classes rather than the full thirteen: sands, fine sandy loams, coarse sandy loams, medium soils, heavy soils. These will serve for purposes of discussion and except for considerations of accurate data would be generally sufficient.

The various colors on our soil map are given in the map legend as soil types. From the definition of soil type, which I have given you, all lands included in areas of the same color should be identical in character and consequently in production. Actually they are not. That is principally the fault of the detail of our survey. If the soils of an area were completely, thoroughly and accurately mapped to show all areas of soil types, large and small, we would seldom have such large unbroken areas of color as we have shown. That is, if every area of a soil type were actually shown on the map, we would have a map which would (to use homely terms) more nearly resemble freckles than shades of tan. In other words the color masses are necessarily quite conventional. However, in most cases, at least, all lands in a given color area are predominantly of the type described and the typical soils within it will be off type to such slight degree or will be of such small extent, as to be relatively unimportant under extensive agricultural conditions such as ours. Slopes, depressions and exposure, with consequent differences in drainage, erosion, deposition and temperature, will cause minor variations over fairly large areas and sharp variations over small areas which cannot be shown on maps of extensive surveys. To show soil variations in such minute detail would result in far greater expense and much slower progress for our soil survey. Everything considered the sacrifice is certainly not worth the more accurate map which would result. If, however, such a detailed

survey were needed for a comparatively small area, for some special purpose, it could be made by an experienced man with sufficient time for the task.

To summarize our classification scheme, there is a close correlation of soil character with various genetical soil factors, namely, elements of climate, natural vegetation and parent materials. Other factors such as texture, micro-organic life, topography, etc., are largely expressed by and included in the above factors and are therefore secondary in importance.

Soil character itself, considering the whole soil profile, from the surface well into the unchanged parent material, seems to be the most logical basis for classification. However, the above genetical factors outline natural soil divisions so well that the grouping of soils largely parallels the occurrence of these factors. Our classification is therefore closely associated with climate, geological origin and natural vegetation, and an understanding of these relations greatly simplifies the matter of soil classification and enlarges our understanding of various elements of soil character.

The major groups will be determined by climate, secondary groups usually by geological origin and final or species groups by differences in texture. Soil differences within areas of a given soil tpe, due to minor differences in gradient of slope, relative elevation and exposure are ordinarily disregarded in our soil mapping but could be taken care of by a very detailed type of survey.

I have not gone into the specific chemical and physical soil changes accompanying the various groups of genetic factors and stamping the soils with their particular character. Those are matters for a separate discussion.

Representative Soil Types, Their Natural Vegetation and General Agricultural Adaptations

I have selected three representative and extensive Saskatchewan soil types, from three different climatic soil groups, for the purpose of pointing out major differences in character, natural vegetation and agricultural adaptations. We are studying natural vegetation along with our soil classification and are finding some very interesting correlations, many of which will be brought out in our reconnaissance soil reports. It seems to me that natural vegetation will reveal a great deal as to the suitability of lands for agricultural purposes.

The table gives, first, the essential characteristics of the soil types, second, the predominant forms of natural vegetation and third some of the more essential features of the agriculture of each type. Soils of the same texture and same geological origin have been purposely selected in order better to illustrate differences of the broader soil belts and the climatic areas. The three soils vary markedly in color and humus content, depth of lime layer, structure and water holding capacity. There are also marked differences between two of the three in reaction and drainage.

Soil Characteristics, natural Vegetation and Agricultural Features of Soil Types of Three Zonal Soil Belts

Soil Character	OXBOW LOAM (A black park soil)	WAITVILLE LOAM (A northern timber soil)	CADILAC LOAM (A brown plains soil)
Texture	Loam	Loam	Loam
Geological Origin	Glacial till	Glacial till	Glacial till
Color	Black	Light grey	Brown
Humus	High	Very low	Moderate
Reaction	Neutral or slightly alkaline	Acid	Neutral or slightly alkaline
Lime zone	About 16 inches deep	About 30 inches deep	About 12 inches deep
Surface structure	Fine granular and loamy	Powdery and lumpy	Fine granular
Subsoil	Moderately heavy	Moderately heavy	Moderately heavy
Drainage	Numerous sloughs. Higher lands well drained.	Good except in the occasional marshes	Good. Few sloughs
Topography	Undulating	Undulating to rolling	Undulating to rolling
Stoniness	Moderate to very	Moderate to very	Moderate to very
Natural Vegetation Associations	Bluffs of aspen and willows. Prairie spaces with tall grasses, mostly of genera *Poa, Agropyron, Bromus* and *Calamagrostis.*	Thick timber of aspen, balsam poplar and birch, Little grass mostly *Avena striata,* considerable wild peavine and wood flowers such as fireweed. A number of acid soil plants such as cranberry, hazelnut, strawberry.	Short and medium grasses (*Bouteloua gracilis, Stipa comata, Koeleria gracilis, Agropyrons dasystachyum* and *Smithii*) Sage bush (*Artemisia cana*) and mountain sage (*Artemisia frigida*).

Agriculture	OXBOW LOAM (A black park soil)	WAITVILLE LOAM (A northern timber soil)	CADILAC LOAM (A brown plains soil)
Development	Generally well developed with good farmsteads. A fair proportion of undeveloped lands.	Little developed. Farms small and buildings poor.	Well developed. Good farmsteads and mostly cultivated.
Wheat grain	Piebald frequent. Not as flinty as in dry areas.	Piebald common. Usually No. 2 or poorer.	Hard, flinty, seldom piebald. Frequently shriveled from drought.
Wheat straw	Usually taller and heavier than on prairie and plains with frequent lodging.	Moderate height and weight.	Usually fairly short.
Oats	Usually produce well.	Fairly good crop.	Fairly difficult crop unless given careful attention.
Grasses	Medium and tall. Usually thick stand.	Thin stand. Few species.	Short and medium. Fairly thin stand, high quality.
Sweet clover	Does well.		Requires fairly careful attention.
Fertility	High N. Some response to P. and K. Generally high fertility.	Low N., low lime and available phosphorous.	Very fertile.
Workability	Moderate draft.	Moderate draft.	Moderate draft.
Moisture	High moisture capacity, occasional drought.	Fairly droughty.	Frequent insufficient moisture.
Values	$15-$30 improved.	$3–$20 improved.	$25–$30 improved.
General Farming System	Manitoba type of farming with mixed systems generally. Fallow every third or fourth year. Marquis wheat considerably replaced by other crops.	Mixed farming general. Operations on a small scale. Clearing a serious problem. Fallow every 3rd to 5th year, or not yet begun.	Mostly Marquis wheat, with a little oats and barley. Fallow every 2nd or 3rd year.
Principal Crops	Marquis wheat, marcaroni wheat, rye, barley, oats, and a fairly large acreage of forage crops.	Wheat, oats, barley, potatoes.	Marquis wheat with far less oats and barley. Little forage grown.
Pests & Special Difficulties	Rust, wild oats and other weeds serious.	Wild oats, other weeds and rust. Clearing.	Russian thistle and other southwest weeds; hot winds.

The straw of grain is frequently so tall and rank in the black park lands that lodging is fairly frequent. This is in marked contrast to conditions on the plains.

In natural vegetation the soils have little in common. The Oxbow type has the poplar bluffs and interspersed tall grass prairie with species of *Agropyron, Bromus, Poa* and *Calamagrostis* predominating and the shrub, snowberry (*Symphoricarpus occidentalis*) abundant.

The other moist climate type, the Waitville Loam, has a thick stand of poplar timber and associated shrubs such as hazelnut, dogwood, willows, and wild cranberry. Most of these shrubs are common to humid acid soil regions. There is little grass but frequently considerable wild peavines.

The Cadillac Loam has only a comparatively thin stand of grass of the dry belt species, viz., Buffalo Grass (*Bouteloua gracilis*) Spear Grass (*Stipa comata*) and June Grass (*Koehleria gracilis*). Mountain sage (*Artemisia frigida*) is a common herb and Sage Brush (*Artemisia cana* and *tridentata*) are common shrubs.

The differences in agricultural practices are marked and in agricultural adaptions fairly obvious. On the Cadillac Loam the tendency is to fallow every other year to conserve moisture and to check Russian thistle. On the Oxbow Loam the fallow practice is every third or fourth year to conserve moisture and to control a greater variety of weed pests than exist in the Cadillac belt. Other noticeable differences are in quality of wheat, length of straw, success with oats, grasses, sweet clover and other crops; in fertility; moisture capacity, pests and diseases, implements and cultivation practices, and adaptability to live stock production. I have purposely omitted discussing the agriculture of the Waitville Loam, in order to simplify the comparison. The variations is agriculture with that type included in the comparison are at least as marked as those roughly outlined for the other two types.

University of Saskatchewan,
Saskatoon, Sask.

A TIME AND LABOUR SAVING METHOD FOR THE PREPARATION OF LEGUME CULTURES

Donald Bethune Shutt,

[Received for publication April 13, 1928.]

The season for the preparation and distribution of legume cultures always comes when there is a shortage of time. Teaching and routine work is at its height and the additional work taxes to the utmost those whose duty it is to attend to this work. In order to simplify the system the writer visited several laboratories in the United States and Canada where large quantities of cultures are prepared annually, and obtained from them various ideas from which the following system has been evolved. No claim is made for originality except in a few minor points, which were necessary to fit the methods together to suit the task.

Equipment Required

The only special apparatus required, other than autoclaves and a steamer for preparing media and incubator, are the following:

Metal trays to suit autoclaves,
Factory cotton strips to cover trays,
Pressure pump, electric,
Atomizers.

Method

Either Ashby's Agar or the following modification may be used;

Agar	20 grams.
Cane Sugar	10 "
$Ca_3(PO_4)_2$	1 "
$Mg_3(PO_4)_2$	1 "
K_2SO_4	1 "
Na Cl	0.1 "
Tap water	1000 cc

Mix the agar with the water and heat until melted. Then add the chemicals and heat for fifteen to thirty minutes. Add the cane sugar and 70 grams of Ca CO_3 just previous to bottling. The above medium supplies good growth in from five to six days when incubated at 25°C.

The bottles preferred are the King Oval 2 oz. These bottles are rugged in construction and will withstand much hard usage in the mails and elsewhere. They are placed in metal trays, made especially to suit the autoclave and in our laboratory each tray will hold fifty bottles. The sides of the trays are extended upwards two inches to give support to the bottles. The trays are perforated on the bottom to allow steam to circulate.

Partially fill the bottles so that when sloped they give a maximum surface. When the bottles are filled they are not plugged with cotton, but instead two strips of factory cotton are tied securely over the whole tray. The string will fit closely below the lip of the bottles.

By designing the trays so that two trays can fit the autoclave, side by side, it is possible to place from three to five trays in an autoclave at one time. Short strips of wood, one inch thick, placed beneath the upper trays will allow sufficient steam to circulate. Autoclaving is carried on for thirty to forty minutes at twenty pounds pressure. When the pressure is down the trays are removed and sloped by inclining the whole tray on a strip of wood. When the agar has set the slopes are ready for inoculation.

Special atomizers have been constructed for this laboratory by the De Vilbiss Mfg. Co., which will hold sufficient material to inoculate one thousand slopes. The atomizer is sterilized in the autoclave before use.

An electric pressure pump supplies the pressure needed to operate the atomizer and the intake to the pump is protected from contamination by a piece of rubber tubing into which a sterile filter has been placed. The filter consists of a piece of glass tubing packed with absorbent cotton. The rubber tubing is steamed previous to operating. A long stretch of rubber tubing extends from the outlet of the pump and connects with the atomizer. This is also steamed well before use.

Four representative mother cultures of the strain of *Ps. radicicola* to be used are flushed with sterile water under aseptic conditions and the bacteria are then transferred back to the water flask through a metal strainer, which has been sterilized in the flame just prior to use. The metal strainer ensures the elimination of bits of agar and other sediment which would otherwise clog the atomizer. The mixture of water and bacteria is then poured into the atomizer.

The process of inoculating the slopes is a simple one. The tray is placed on a bench near the electric pump and the cotton cover is carefully removed and placed in a solution of Izal, (1:300). The mouths of all the bottles are next flamed with a bunsen burner. The electric pump is started and when the pressure is sufficient, the nozzle of the atomizer is inserted into each bottle in turn until sufficient of the mixture covers the surface. With our pressure and atomizer four seconds to a bottle is enough. When all the bottles in the tray have been inoculated the pump is stopped and the cotton cover is replaced and tied over the whole tray. The cotton cover is previously wrung out.

It is possible with this method to inoculate one thousand cultures or more in a day.

The trays are incubated at 25°C. for six days. Growth is then apparent on the surface as a thick slimy mass.

The bottles are corked by hand. A pot of water and corks is placed upon a gas burner and brought to the boil. The cotton cover is removed from the tray and all the mouths of the bottles flamed. With forceps a cork is removed from the boiling water and inserted into the mouth of a bottle and pushed home by a rotary motion.

The above methods have been used successfully by the writer for the last two years. Care must be taken to keep dust at a minimum and to exer-

cise caution when transferring the mother culture to the flask of sterile water and later to the atomizer. If mould spores should contaminate the mixture much trouble will ensue.

Summary

Much time and labor may be saved in the preparation of legume cultures by placing the bottles in large trays and covering the whole tray after filling, with two thicknesses of factory cotton, instead of plugging each bottle with cotton.

Inoculation of the slopes is greatly speeded up by the use of an atomizer.

Acknowledgements

The writer is indebted to R. M. Snyder, Ph. D., of the Laboratory of Bacteriology, Michigan State College, from whom many of the ideas were collected. Also to the De Vilbiss Manufacturing Company of Windsor, Ontario, who co-operated in the preparation of the special atomizer.

Ontario Agricultural College,
Guelph, Ont.

NOTE

The University of Alberta is enlarging the accommodation of its Department of Field Crops this year by the erection of a new laboratory and greenhouses for plant pathology and plant breeding. This additional space will make possible the carrying out of a cooperative attack by the University, the Federal Department of Agriculture, and the National Research Council, on the problem of root-rot diseases. Dr. A. W. Henry, formerly of the University of Minnesota, on his return from Europe last fall joined the staff of the Department of Field Crops, and will lead the plant pathological work for the University. Dr. G. B. Sanford, of the Federal Division of Botany, will have charge of the Dominion Laboratory of Plant Pathology, which will be accommodated by the University in the same building. Dr. O. S. Aamodt, of the University of Minnesota, has been appointed to lead the work in cereal breeding for the University. Dr. Aamodt will spend the summer in Europe, mainly at Cambridge and Svalöf, and will take up his work at the University of Alberta next fall. Professor J. R. Fryer will continue in charge of forage crop breeding. Disease resistance is one of the main qualities sought in the breeding work.

R. Newton.

ERRATUM

In the May issue, on page 567, a footnote stated that the paper "Self-cleaning thresher for single plants", by Dr. J. B. Harrington, had been read at the annual meeting of the Western Canadian Society of Agronomy. This statement is not correct and the footnote should be deleted.—Editor.

LA CLASSIFICATION DES SOLS DANS QUEBEC*

Auguste Scott

Un problême qui a toujours intéressé les différents peuples a été le maintien de la fertilité de leurs sols. En Chine, durant la dynastie des Yao (11), en l'an 2357 à 2261, l'empereur du temps décida de classifier son sol en 9 types différents. Sur chacun d'eux, il détermina la grandeur des propriétés de chaque fermier, le montant de taxes à verser à l'Etat et il établit un système d'éducation agricole conforme aux méthodes culturales adaptées sur chacun de ces types distincts.

Dans les écrits des anciens Grecs et des philosophes romains nous voyons que ces gens avaient une connaissance assez avancée sur les relations du sol avec la plante. L'histoire agricole du nord de l'Europe nous montre les connaissances que ces gens avaient des plantes et de leur habitat.

Partout on a toujours su que là où l'agriculture est prospère l'économique de la nation est absolument stable. Mais le succès ou la faillite en agriculture ne dépendent-ils pas en majeure partie de la capacité de production du sol? Si la prospérité agricole est si intimement liée au sol, il va sans dire qu'une étude détaillée de celui-ci est de toute première nécessité.

Le problême du maintien de la fertilité du sol ne s'est pas encore posé d'une façon très ardue, pour nous de la province de Québec. Mais en sera-t-il toujours ainsi? Bien que bon nombre de nos terres soient fertiles, une chose absolument certaine, c'est que les méthodes de cultures ruineuses qui sont en vogue dans bien des régions épuiseront bien même les plus productives. L'épi d'or qui était la joie et le soutien de nos grands-pères est souvent chassé de son domaine par la mauvaise herbe.

De plus si notre population continue à augmenter et veut rester chez elle, il nous faudra faire rendre au sol son maximum de production. Comment y parviendrons-nous?...En pratiquant un système de culture rationnel, en exigeant du sol son maximum de rendement; en d'autres termes en suivant les indications données par la classification des sols.

Mais qu'est-ce donc que la classification des sols? Qu'est-ce qu'il y a de fait? Quelle est son utilité pour la province de Québec? C'est justement la reponse à ces diverses questions qui nous a poussés à entreprendre le présent travail.

- I PARTIE. - APERCUS GENERAUX

Ce Qu'est La Classification des Sols

Lorsque nous parlons de classification des sols, nous entendons une classification telle qu'on la fait aux Etats-Unis. Il y a ailleurs d'autres systèmes de classification, comme nous le verrons un peu plus loin, mais ils ne

*Thèse présentée pour l'obtention du diplôme de B.S.A. à l'Ecole d'Agriculture de Ste. Anne de la Pocatière.

nous intéressent guère; en effet, ils ne semblent pas aussi bien répondre aux besoins de la province de Québec que celui de nos voisins; d'ailleurs c'est celui qu'ont adopté les autres provinces du Dominion qui font ce travail.

La classification suppose au préalable une étude ou enquête des sols (Soils Survey). Dans ce travail, on recherche la nature et la situation des sols dans le champ; la position de ces différents sols est notée sur une carte avec chacun leurs propriétés culturales et leurs relations économiques. D'après Whitney, ce serait le groupement des sols d'après leur texture, leur structure, leur position physiographique et leurs relations culturales indiquées sur une carte.

Les facteurs que l'on emploie comme base de classification sont au nombre de six: (4) 1)—texture 2)—propriétés spéciales, particulièrement les propriétés chimiques, 3)—espèces de matériel d'où provient le sol, 4)—agents de formation, 5)—humidité et précipitation, 6)—température normale et moyenne.

Le type de sol (soil type) est l'unité en classification; on pourrait le définir une aire de sols essentiellement semblables dans toutes les propriétés citées plus haut.

Les sols peuvent avoir même texture, tout en se différenciant par d'autres propriétés; ces sols de même texture constituent ce que l'on appelle une classe de sols (soil class).

Des sols peuvent être de texture différente avec par ailleurs d'autres propriétés semblables. Ils peuvent être de même couleur, être pauvres en chaux, etc., etc. Un tel groupe de sols différents quant à leur texture, mais se ressemblant par d'autres propriétés, constituent une série de sols (soil series).

Les sols de différentes séries pourront être formés des mêmes espèces de roches mélangées à peu près dans les mêmes proportions. Ces différentes séries ainsi constituées formerent ce que l'on appelle un groupe de sols (soil group).

Tous les sols qui ont été formés de la même facon, soit par l'eau, soit par les glaciers forment le groupement le plus général que l'on appelle province de sols (soil province).

Disons tout de suite que ce travail comprend deux parties distinctes: le travail accompli par des inspecteurs sur le champ et le travail effectué dans le laboratoire. Ce travail accompli dans le champ se fait ordinairement par deux hommes (4). Si l'on ne veut que faire une classification sommaire ou préliminaire, ces hommes parcoureront la région à étudier, pour avoir une idée générale des principales aires. On forera le sol en certains endroits, pour se rendre compte du changement de sol. On indiquera ensuite sur une carte la position des différentes séries de sols (5). Dans cette classification, l'analyse chimique et physique ne sont pas absolument nécessaires; elles ne servent que pour préciser et confirmer les observations faites sur le terrain. Plus la classification sera détaillée, plus on se servira de ces données analytiques, dit C. W. Robinson (37).

Si l'on veut avoir des données plus précises sur la valeur des sols, il faudra recourir à la classification en détail. Ce travail se fait beaucoup plus lentement et nécessairement coûte plus cher. Dans ce travail, les inspecteurs vont dans chaque partie du champ à classifier; ils pratiquent différents forages, prennent note de l'apparence du sol, de la topographie, de la conformation de la contrée, du caractère de la végétation. Ils doivent aussi étudier la relation qui existe entre le sol et les plantes, ainsi que ses propriétés culturales. On prend soin ensuite d'interviewer le cultivateur sur ses façons de culture et la réponse que le sol fait à l'application des divers engrais.

Ils prennent note de tous ces détails concernant les différents types de sols et font un graphique illustrant chacun d'eux. Ils indiquent aussi sur ce graphique les endroits où one été pris les différents échantillons. Notons en passant que ces prises d'échantillons doivent être beaucoup plus nombreuses là où se fait le changement d'un type de sol à un autre, afin de pouvoir mieux établir les limites. On envoie ensuite un échantillon préliminaire des différents types de sol, pour s'assurer de la justesse du jugement de l'inspecteur.

Quand celui-ci est familier avec les différents types de sols, il en prend des échantillons bien représentatifs. Chaque échantillon est ordinairement divisé en deux: Une partie représenté le sol et l'autre le sous-sol. Ces échantillons sont envoyés au laboratoire où on en fait l'analyse mécanique et chimique.

Ce travail fait, on dresse alors le rapport et la carte agronomique l'accompagnant qui seront envoyés à tous ceux qui y sont intéressés. Dans ce rapport, la description des sols se fait de deux façons différentes:

1)—On groupe les différents types de sols en séries ou en plus grande division, on donne les relations géologiques et topographiques de chacun de ces groupes, avec un exposé clair des caractéristiques principales de chaque groupe, comme par exemple le manque de chaux, la qualité du drainage, etc.

2)—On donne une description détaillée de chaque type de sol: sa couleur sa profondeur, sa texture, sa structure particulière, ses propriétés chimiques et minéralogiques. En plus de cela, on doit donner une idée de sa situation, son étendue, son mode de formation, ses conditions d'égouttement et ses relations économiques, incluant la rotation des cultures et les cultures spécialisées qu'on y pratique ou qu'on pourrait y pratiquer.

La carte agronomique qui acompagne le rapport est destinée à faire voir les différents types de sols et leur fréquence. Chaque type de sols est représenté par une couleur spéciale. L'échelle de un pouce au mille est la plus communément employée aux Etats-Unis. Cependant dans la classification sommaire, on emploie l'échelle de six milles au pouce.

La Classification des Sols dans les Differents Pays.

Nous ne nous attarderons pas à étudier les différents systèmes de classification des pays de l'ancien monde. Un mot simplement pour avoir une idée du travail qu'ils font.

En France (13), le travail s'accomplit par chaque département en particulier; le travail se fait sur la base pétrogéologique ou minéralogique. En Angleterre (13), il y a différentes méthodes de classification variant avec chaque district. Cependant dans la majorité des cas, comme dans les districts de Surrey, Sussex et Kent, on considère la formation géologique comme base de classification. En Suède (1), la seule base est l'état où se trouvent les sols par rapport à leur genèse. En Finlande (1), le processus de la formation chimique et physique des sols sert comme principe fondamental de la classification. En Allemagne (1), les sols sont classifiés d'après les propriétés chimiques du terrain. En Roumanie (1), la classification est basée sur l'étude du profil agrogéologique. En Norvège (1), l'analyse mécanique sert de base à la classification. En Italie (2), la classification scientifique des terres doit considérer comme fondamentale la détermination de la phase évolutive lithologique. Si nous voulions énumérer tous les pays qui font de la classification, nous les repasserions pratiquement tous; mais nous terminerons là cette énumération, pour nous arrêter d'avantage sur le travail qui se fait aux E.-U.

Ces différents pays ne sont pas aussi avancés dans ce travail que le sont les Etats-Unis; car, dit Buckman (4), ils ont à peine quelques milliers d'acres de classifiés, tandis que les Etats-Unis en ont plusieurs millions.

Le Bureau des sols de Washington a fait beaucoup de travail, pour contribuer à l'avancement de la classification des sols dans les différents états. En 1899, il n'y avait pratiquement pas de classification. La Caroline du Nord commença le travail en 1901. Le 1er janvier 1915, 330,000 milles carrés avaient une classification détaillée et 435,000 milles carrés avaient une classification sommaire. En plus de cela, les Etats-Unis avaient fait de la classification à Porto-Rico, Panama, Iles Philippines et Alaska (4).

En 1917, 479,059,000 acres des sols américains étaient classifiés (6), soit 25.2%. En 1920, sur les 3,043 comtés américains, 926 avaient une classification de détail; l'étendue totale alors classifiée s'étendait à 547,733 milles carrés, ce qui égale la Grande-Bretagne, l'Irlande, la France et l'Allemagne avant la guerre (8). En 1922, la Géorgie (18) avait 181,760 acres de classifiés. Le Rhodes-Island et New-York ont une classification complète; l'Illinois a plus de 60% de son sol de classifié et le Kentucky en a dans plusieurs endroits. On peut dire qu'aujourd'hui il y a de la classification dans absolument tous les Etats de la République Américaine. Durant l'année fiscale se terminant le 30 juin 1925 (32), les Etats-Unis avaient fait de la classification sur 27,837 milles carrés. En 1927, le Bureau des sols des Etats-Unis (27) avait classifié et fait l'expertise d'un total de 1,200,000 milles carrés, soit 43% de leurs terres.

Voilà en peu de mots la somme énorme de travail de classification qui s'est fait à l'étranger. Qu'est-ce que le Canada a fait durant ce temps? Certaines provinces comme Québec n'ont pratiquement rien fait; d'autres cependant, comme la Colombie-Anglaise, le Manitoba, la Saskatchewan, L'Ontario ont déjà tourné passablement leurs efforts en ce sens.

Dans les provinces de l'Ouest, il s'est fait passablement de travail sur les sols. En juin dernier, lors du Congrès International sur la Science des Sols, tenu à Washington, F. A. Wyatt et J. D. Newton (37) donnèrent un intéressant travail sur les sols d'Alberta, intitulé: "Alberta Soils Profile".

En Colombie-Anglaise, il se fait quelque peu de classification, mais, dit W. Newton (28), cela n'avance pas très vite, car l'opinion populaire ne lui est pas très favorable. Cependant quelques régions sont classifiées, car le "B.C. Agricultural Journal (34) publiait un rapport de classification de "Terrace District" où on conseillait fortement la culture des petits fruits.

Au Manitoba, comme nous l'écrivait en octobre dernier, l'Honorable Albert Préfontaine, Ministre de l'Agriculture et de l'Emigration, il n'y a pas de travail de fait s'étendant directement à cette matière, mais il a été publié en 1926 un rapport (35) donnant de très précieuses indications sur la valeur des sols. Ce travail est effectué sur les mêmes bases que celui de la classification des sols proprement dits, avec cette différence qu'il porte principalement sur les terres qui ne sont pas encore en culture.

C'est en Saskatchewan qu'il se fait le plus de classification; ce travail fut commencé en 1923, sur la demande des cultivateurs réunis en conférence à Swift Current (33). Une résolution fut passée pour demander au Ministère de l'Agriculture une classification des sols pour parer aux malaises actuels de l'agriculture et pour encourager le développement des différents types de sol, suivant les modes de culture qui leur sont les mieux adaptés (26). Le travail se continue sans interruption, puisqu'en avril 1927 paraissait le sixième rapport complétant la classification de 24 municipalités (26). Le Professeur Hansen (25) se dit toujours très enthousiaste du travail. Même on trouve que le travail ne se fait pas encore assez vite; on est même allé jusqu'à faire passer une résolution (33), demandant de faire immédiatement une classification sommaire sur toutes les terres cultivées.

Les provinces de l'Ouest ne sont pas les seules à s'occuper de classification; ainsi en Ontario le travail de classification commença même plus à bonne heure qu'en Saskatchewan. A. J. Galbraith (15) commença en 1914 un travail de classification sommaire; il le continua en 1915, mais très lentement, car ce travail était nouveau pour lui. Durant les étés de 1916 et 1917, M. Wodward le fit avancer considérablement; mais ce ne fut qu'en 1918 que la classification des sols prit un nouvel essor sous la conduite de W. L. Iveson qui s'était spécialisé en cette matière. Il poussa activement le travail jusqu'en 1920 où il mourut subitement, avant d'avoir pu rédiger complètement les notes qu'il avait prises, dans son travail d'inspection sur le champ. Cette mort prématurée eut pour effet de paralyser le travail de classification; ce ne fut que durant la dernière partie de l'été de 1922, qu'on recommenca une classification de détail sur les sols de Kent County où environ 100 milles carrés furent cartographiés.

En 1923, toute la partie sud de l'Ontario avait une classification préliminaire. Cette classification encercle tout le sud de la baie Nottawasaga, s'étend jusqu'au nord du lac Simcoe et se continue en ligne pratiquement

droite vers l'est, pour aller frapper le lac Ontario à une dizaine de milles au nord de la ville de Kingston.

Nous du Québec, qu'est-ce que nous avons fait durant ce temps? Au point de vue direct de classification des sols en ce qui regarde l'agriculture, nous n'avons rien fait. Le seul travail de classification qui se fait depuis quelques années a été entrepris par le Ministère de la Colonisation. Dans cette classification, on indique seulement si un sol est colonisable ou non; on ne s'occupe pas de sa plus ou moins grande valeur agricole, ni de sa situation par rapport au marché présent ou futur. Nous ne contestons pas l'utilité de cette classification, mais nous croyons qu'elle ne semble pas rendre tous les services qu'elle pourrait rendre, si elle était faite suivant le mode de classification que l'on a adopté dans les autres provinces. En effet, cette classification ne peut servir que pour la détermination des lots colonisables ou non, tandis qu'autrement elle servirait et au point de vue colonisation et au point de vue agricole, puisqu'elle indiquerait la valeur intrinsèque du fond de la terre.

S'il ne s'est pas fait de classification, il ne faut cependant pas prétendre qu'il ne s'est fait aucun travail sur les sols. Au contraire, on s'est beaucoup occupé de l'analyse chimique des sols. Depuis 1916, le Laboratoire Officiel Provincial de St-Hyacinthe effectue chaque année un nombre considérable d'analyses chimiques de sols. Ainsi de 1916 à 1924 inclusivement il a été analysé à St.-Hyacinthe 340 échantillons de sols.

Sans aucun doute ces analyses rendent d'appréciables services à ceux qui les font faire, mais est-ce qu'elles en disent autant sur la productivité des terres que si elles étaient en relation avec la classification des sols? En effet, l'analyse chimique ne peut guère par elle-même donner beaucoup de renseignements sur la valeur productive d'un sol. C'est ce que mentionne M. H. M. Nagant, professeur à Oka, dans un article paru dans la Revue Trimestrielle et reproduit dans le journal d'Agriculture (31). "Les analyses de sols que publie chaque année le directeur du Laboratoire Officiel Provincial sont sans doute intéressantes, mais nous regrettons que ces résultats ne soient pas en rapport avec le travail de classification des sols."

Si l'étude des sols au point de vue de leur adaptabilité aux différentes plantes n'a pas été tentée dans Québec, il faut dire cependant qu'il s'est fait beaucoup d'études des sols au point de vue géologique. Ainsi en 1914, le Ministère des Mines d'Ottawa publiait une série de petits livrets-guides qui donnaient le résultat d'excursions faites dans les différentes parties du Canada (36). Sur les treize livrets de cette série, quatre sont consacrés à l'étude des sols de la province de Québec.

Plus tard en 1916, 1917, 1918, on pratiqua de nombreuses investigations dans la région de Beauceville (30). On y a fait une étude très détaillée des sols de cette région. Encore dernièrement nous voyions annoncé dans un journal, un opuscule publié par la Commission Géologique du Canada et intitulé: "La région cartographiée du mont Albert (Québec). C'est une étude d'une partie du Québec, la Gaspésie, qui, prétend-on, est si riche en mines.

Ces différents travaux, tout en étant fait au simple point de vue géologique seraient d'une très grande utilité pour le travail de classification des sols. En effet, la formation géologique des sols est un facteur important dans la classification même en certains pays, comme le pays de Galles en Angleterre, elle servit de base pour la classification des sols (1).

D'autres travaux absolument essentiels pour la classification des sols sont encore tout préparés dans la province de Québec. Ainsi il y a des relevés topographiques de faits un peu partout ici dans la province. Pour ce qui regarde le climat, il y a distribuées dans tous les points de la province 84 stations météorologiques qui enrégistrent à peu près tout ce qui regarde le climat et la température.

Voilà autant de données que la classification des sols requiert et qui sont toutes prêtes. Quelle utilité retirerait le cultivateur de toutes ces données, si elles accompagnaient les résultats donnés dans le rapport de classification des sols: Tandis que telles quelles, elles ne sont pratiquement pas utiles, du moins pour le cultivateur et l'agriculture.

(à suivre)

NOTE

Nous sommes informés que la N. V. Potash Export My., of Amsterdam, Hollande, a ouvert, depuis le premier mai, un Bureau canadien, au No. 814 de l'Edifice de la Banque Royale du Canada, 360 rue St. Jacques, à Montréal. C'est notre confrère de la C.S.T.A. monsieur Henry E. Lefèvre, précédemment attaché au Bureau de New York de la même société, qui a pris la direction de la succursale canadienne.

On sait que l'objet de la N. V. Potash Export My. est de faire de la propagande pour l'emploi rationnel des engrais potassiques.

Nous profitons de l'occasion pour souhaiter à notre confrère, Henry E. Lefèvre un plein succès dans le travail qu'il entreprend au Canada.

BOOK REVIEWS

FARM RELIEF, by Dr. James E. Boyle. (Doubleday, Doran & Co., Garden City, N.Y.).

This book is mainly an analysis and criticism of the McNary-Haugen Bill. It is much more than this. In addition to pointing out the weaknesses and impracticability of this bill, this book analyzes the reasons why farming compares somewhat unfavourably with some other industries in general prosperity. An alternative measure of relief for the industry is presented. The need for a comprehensive agricultural policy is emphasized. Perhaps the most interesting contribution of this book, particularly for the Canadian reader, will be the analysis of the reasons for the lack of prosperity, the alternative relief program proposed, and the agricultural policy suggested.

The post-war depression of the farming industry is attributed in large measure to the expansion of the industry during the previous half decade. This is emphasized in the first chapter. Previous depressions are considered, the value of farm land and the proportion of tenancy is given for several decades. A comparison of farm prices and farm expenses and a consideration of the present status of the industry leads the author to conclude that sound and permanent measures of relief are warranted.

The McNary-Haugen Bill offers no hope. The unsoundness and impracticability of this measure is pointed out in a detailed analysis which comprises the major portion of this work. The aim of this measure is to "make the tariff effective" by dumping the surplus while maintaining the domestic price at a higher level. Obviously this scheme may be applied to only certain farm products. Wheat is one of the crops included. In the case of wheat the result would be (assuming that the scheme would work) that over two thirds of the farmers, who do not grow wheat, would be penalized (as well as everybody else) to benefit less than one third of the farmers of the country, who are wheat growers. Other examples are given. The inclusion of only certain crops reveals the unfairness of the proposal. The main objection is that the legislation would not help the farmer. The proposal interferes with supply and demand. Such interferences are frequently popular but at best are only temporarily effective. An endeavour is made to deal with the marketing of the surplus while ignoring production. This is neglecting the more important factor. Further, the existence and popularity of anti-dumping clauses in the tariff legislation of other countries render the scheme practically hopeless. The remedy is hopeless, not being based on a correct diagnosis of the disease.

Agriculture suffers from a lack of balance or adjustment in development, unbalanced production and a lack of orderly marketing of perishables.

Various agencies are active in expanding the farming industry even while the business is unprofitable. The six million odd farmers are disorganized and not very efficient producers. This is termed the anarchy of production. The marketing of perishable products—quite a different under-

taking from the marketing of non-perishables—allows alternate gluts and scarcity. The condition indicates the need for a national agricultural policy.

Considerable progress has been made in certain states towards the regulation of the expansion of farming. The Institute for Research in Land Economics is a valuable recent development in securing data for the systematic development of natural resources. To secure orderly development and balanced production a national agricultural policy is essential. Such a national policy could be provided by a representative board of technical authorities mobilizing and utilizing available information. The policy could not compel but might persuade. Such an organization, by applying nationally the information now available, might lead the industry out of some of its present disorders.

J.E.L.

Other Days Other Ways, by Georges Bouchard, M.P. (Louis Carrier & Co., Montreal, P.Q., $2.50).

Old customs and traditions die hard. Those who are old enough to look back into the days of a generation or two ago, like nothing better than to talk of the vogues and practices of their youth; those who are comparatively young, and patient enough, can spend a pleasant hour listening to such reminiscences. This is the privilege of age and one of the pleasures of youth.

Quebec is an old province. In its rural districts its *habitants* have fought the inroads of commerce—vainly, it is true, but with such doggedness that many of its old customs prevailed until the present generation and some even persist today. It is a province full of history and of customs quaint to most of us. Its people are contented and strangely happy in the face of what most of us would call adversity. They are a fine people to visit, hospitable, always cheerful, always ready to join in a *chanson* or a *p'tit coup*.

Georges Bouchard is a young man, just entering his forties. Born and raised on a farm in Quebec, he has remained loyal to his native province. He graduated from Laval in 1908, spent some time in Belgium and France at the Universities of Louvain and Angers before the war and just recently received the degree of I.A.(Ingénieur Agriculteur) from the latter institution. Since 1922 he has represented his County (Kamouraska) in the House of Commons at Ottawa. He has been an *Agronome* and is now a teacher of Entomology and Zoology at Ste. Anne de la Pocatière. He is a member of the C.S.T.A. and a good fellow.

So much for the province and the author. His book, "Other Days Other Ways" is a blending of both. In it you see the youthful Georges receiving his childhood impressions of the old fiddler, the curé, the schoolmistress, the bone-setter, the cobbler, the blacksmith and all the other characters now so rarely seen, even in Old Quebec. For twenty-five years he has carried these impressions and now he puts them into charming "silhouettes"

so that all may know his province as it was and, probably, as he would still like it to be.

The book is illustrated with wood cuts by Edwin Holgate and prefaced by the Hon. Rodolph Lemieux. It is not a long book and can be read in a couple of hours. But in those two hours, if you could close your eyes and fill your pipe with *tabac canayen,* you would smell the earth and you would realize why the *habitant* of Quebec is what he is.

F.H.G.

CONCERNING THE C.S.T.A.

Notes and News

William Newton (McGill '14) has received the appointment of Plant Pathologist for the Dominion Department of Agriculture in British Columbia. His address will be Dominion Laboratory of Plant Pathology, University of British Columbia, Vancouver, B.C.

John Reoch (Saskatchewan '24) has changed his address to 2248 McTavish Street, Regina, Sask.

S. E. Clarke (Manitoba '21) has been transferred as Asst. Dominion Agrostologist from the Dominion Experimental Station at Swift Curent, Sask., to the Dominion Range Experimental Station, Manyberries, Alberta.

Gustave Gaudet (Laval '22) who has been District Representative at Edmundston, N.B., for the past year has been transferred to Chatham, N.B.

J. H. Tessier (Montreal '25) has changed his address to Plessisville, Megantic County, P.Q. He is Asst. County Agriculturist.

C. Perrault (McGill '26) has been appointed Asst. Plant Pathologist in the Division of Botany, Central Experimental Farm, Ottawa.

J. Roy West (Manitoba '26) is now with the American Society for the Prevention of Cruelty to Animals, Avenue A and 24th Street, New York City.

J. Wilson (Toronto '23), who has been Assistant Agricultural Representative at Hamilton, Ont., for the past two years, has been made Agricultural Representative at Stirling, Ont.

A. J. Mann, (Toronto '18) formerly Assistant Superintendent, Dominion Experimental Station, Summerland, B.C., has been appointed to the staff of the Tobacco Division as Tobacco Specialist for British Columbia. His headquarters will be at Summerland, B.C.

G. T. Jackson (Toronto '25) who has been Manager of the Saskatchewan Co-operative Creameries, Ltd. at Swift Current, Sask., has been transferred to the Branch at Assiniboia, Sask.

The University of Manitoba conferred the honorary degree of Doctor of Laws on E. S. Archibald (Toronto '08) at the convocation exercises on May 16th.

C. W. Leggatt (Toronto '21), Supervising Analyst in the Dominion Seed Branch at Calgary, Alta., has received his M.Sc. degree from the University of Alberta.

Dr. J. M. Swaine (Cornell '05), Associate Dominion Entomologist, has been elected a Fellow of the Royal Society of Canada.

The N. V. Potash Export My., of Amsterdam, Holland, have opened a Canadian office in the Royal Bank Building, Montreal, under the direction of Henry E. Lefèvre (Paris Nat. Agr. Inst. '20). The following have been appointed representatives of the firm in Ontario, Quebec and the Maritime provinces respectively: E. K. Hampson (Toronto '15), Lucien Therrien (Montreal '17), and J. E. McIntyre (Toronto '21).

The following notes constitute changes of address in the C.S.T.A. List of Members recently published:—

H. J. Siemens (Manitoba '25) has been appointed County Agricultural Agent at Watford City, North Dakota, U.S.A.

B. W. Morton (Toronto '21) is returning to Canada from Porto Rico where he has been Agricultural and Industrial Missionary for the past five years. His address will be 500 Markham Street, Toronto 4, Ontario.

H. S. Cunningham (McGill '17) has accepted the post of Plant Pathologist in Bermuda and sails from New York on June 23rd. His address will be Agricultural Station, Paget East, Bermuda.

D. F. Patterson (McGill '27) has been appointed Junior Entomologist at Vineland Station, Ont. During the summer months his address will be Saint Davids, Ont., where he will be engaged in oriental peach moth investigation.

D. A. Brown (Manitoba '20) who has been Assistant to the Superintendent, Dominion Experimental Station, Morden, Man., has received the appointment of Supervisor of Illustration Stations for Manitoba and Eastern Saskatchewan, with headquarters at the Dominion Experimental Farm, Brandon, Man.

W. Southworth (Toronto '12) has resigned as Professor of Field Husbandry at the Manitoba Agricultural College and is returning to England. His new address is Bushley, Roden Avenue, Kidderminster, England.

Applications for Membership

The following applications for regular membership have been received since May 1, 1928:—

D. E. Arsenault (Toronto, 1921, B.S.A.) Quebec, P.Q.

Reginald Barbin (Laval, 1913, B.S.A.) Quebec, P.Q.

H. Gordon Coburn (Toronto, 1928, B.A.) Toronto, Ontario.

J. E. Edgar (Alberta, 1927, B.S.A.) Fort Saskatchewan, Alta.

L. E. Kindt (Alberta, 1927, B.S.A.) St. Paul, Minn., U.S.A.

Lionel Lafrance (Laval, 1925, B.S.A.) Quebec, P.Q.

Maximilien Lemieux (Laval, 1918, B.S.A.) Iles de la Madeleine, P.Q.

L. D. Mallory (British Columbia, 1927, B.S.A.) Vancouver, B.C.

A. H. Martin (Toronto, 1924, B.S.A.) Renfrew, Ontario.

J. R. Méthot (Montreal, 1918, B.S.A.) Quebec, P.Q.

Frank F. Morwick (Toronto, 1927, B.S.A.) Guelph, Ontario.

H. A. MacGregor (Alberta, 1928, B.Sc.) Edmonton, Alta.

F. A. Peto (Manitoba, 1928, B.S.A.) Edmonton, Alta.

Robert H. Smith (McGill, 1924, B.S.A.) Hudson, P.Q.

Membership

On May 31st, 1928, the total number of regular members was 989, as compared with 987 reported a year ago. The number of student members, however, has increased from 13 to 34, so that the total membership is 1023 as compared with 1000 in 1927. There is no doubt that the membership can be maintained at approximately 1000 without conducting any extensive campaigns; during the past year there were 81 resignations and 6 deaths among the regular membership, and 87 new regular members were admitted.

Finances

At the time of writing, the financial statement for the year ending May 31st has not been completed. It will be audited and printed for distribution at the Annual Convention. In spite of considerable increase in expenditure the credit balance this year is somewhat over $2,000, slightly more than the balance at the close of last year. Consequently, there is little possibility of any increase in membership fees being recommended at the coming Convention.

Progress

The developments during the past year which may be considered as indicating progress are (1) the change in the size and form of the official journal, (2) the donation of $3,000 annually for three years by the T. Eaton Company for the establishment of five scholarships of $600.00 each, (3) a grant of $4,000 from the International Education Board (Rockefeller Foundation) to finance a survey of agricultural research facilities in Canada and the preparation and publication of a Graduate Calendar based thereon, (4) Incorporation and (5) the appointment of a permanent clerical assistant at the central office.

It is obvious that the Society is now firmly established and receiving increasing recognition. None but the most pessimistic can doubt its permanence.

Recommendations

Among the recommendations which will be made in the annual report of the General Secretary, the following may be mentioned:—

1. That a further improvement be made in the quality of paper used in the journal, so that illustrations may be reproduced more clearly.

2. That some consideration be given to the establishment of more adequate headquarters for the Society, such headquarters to include conveniences for members visiting Ottawa during the year.

3. That steps be taken to encourage commercial firms to employ more agricultural graduates and that the records in the office of the General Secretary be made available to all those seeking trained men through the C.S.T.A.

4. That the provision for Life Membership at $100.00 now in the By-Laws of the Society, be made known to all members and that money derived from this source be soundly invested in an Endowment Fund.

If any member wishes to bring any resolutions or recommendations before the annual convention, he may address them to the General Secretary at Room 1101, Chateau Frontenac, Quebec, P.Q. Delivery must be made not later than June 11th. Recommendations for Fellowships or Honorary Memberships should be similarly directed.